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Flowers and Insects,

Contributions

to an account of the Ecological Relations of the Entomophilous Flora and the Anthophilous Insect-Fauna of the neighbourhood of Carlinville, Illinois.

1889-1896.

Contents

[From the BOTANICAL GAZETTE, Vol. xiv, No. 5.]

Flowers and Insects. I.

CHARLES ROBERTSON.[1]

Delphinium tricorne Michx.—The flower agrees in most respects with D. elatum, as described by Müller.[2]

It is blue, but the exposed parts of the two upper petals which arch over the entrance to the spur are white, forming a sure guide to the nectar. In D. Ajacis, according to Sprengel (702),[3] the upper petals also form the pathfinders by a variation in color. In D. elatum yellow hairs on the lateral petals form the guides, while in D. Consolida pathfinders are wanting (Müller).

The lower petal has disappeared, since its attractive function has been usurped by the sepals. It is unnecessary as a protection to the stamens and pistils, and its presence in the median line would only prevent proper contact with the anthers and stigmas.

The parts whose function has been most imperfectly explained are the two lateral petals. These close over the numerous stamens, completely hiding them, but an entrance to the spur is left between them and the upper petals. When a bee visits the flower, the lateral petals are forced aside, and the under side of the bee's head comes in contact with the

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[1] The following series of papers is intended to give the results of observations begun in 1886, near Carlinville, Ill. It has been necessary at first to pay particular attention to collecting and determining the insects. Accordingly, in case of many flowers I am able at present to give only a list of visitors.

Mr. Cresson has compared my bees with his own type specimens in the collection of the American Entomological Society, except species of Halictus and Andrena. Professor S. W. Williston has kindly identified the Diptera. Mr. C. A. Hart and Mr. Samuel Henshaw have aided me in identifying the Coleoptera. Prof. G. H. French and Mr. Hart have named a number of Lepidoptera for me. I am also under obligations to Prof. S. A. Forbes for access to the collections and literature of the Illinois State Laboratory of Natural History, and to Prof. William Trelease for access to his valuable index of the bibliography and to much of the special literature of fertilization. Prof. Trelease has also placed at my disposal his unpublished notes on the subject and a collection of insects which he has taken on flowers.

[2] Unless otherwise specified, all references to Müller are to Herman Müller: Fertilization of Flowers. See also on this species Delpino: Ulteriori Osservazioni, and Lubbock: British Wild Flowers.

[3] The numbers in parenthesis after an author's name refer to Thompson's bibliography of the literature of fertilization, which is printed with Müller's Fertilization of Flowers. As this book is the most important source of information on the literature, references are practically thrown away on all who do not have access to it.

anthers and stigmas. The use of these petals seems to be to protect the pollen from intruders. Sprengel saw bees collecting pollen of D. Ajacis, and I have seen a very abundant and useful visitor, Synhalonia speciosa, collecting pollen of D. tricorne, but I am convinced that they behave improperly in so doing. Humble-bees, which are best adapted to fertilize the flowers, never gather pollen. On the other hand, I have seen Andrenidæ trying to collect it, and they were only hindered by the lateral petals. But for these petals most of the pollen would be carried away by little bees which would only visit flowers in the male stage.

The spur of the upper sepal is crumpled, and sometimes fits the spurs of the petals so loosely that its tip is empty and hangs down. Indeed, in one case I found the upper sepal entirely empty, and the spurs of the petals stood in front of its lamina. Delpino (178) regards the spur of the sepal as a protection against the jaws of insects which might attempt to cut a way to the nectar, but both he and Riches[4] found some species of Delphinium to be perforated.

As in D. elatum, the spurs of the petals are entire at the tips and open below into a common cavity. The nectar, therefore, is held in two receptacles, and I have observed that when Bombus and Synhalonia insert their proboscides into the spur, they regularly draw back a little and thrust their tongues in again, evidently to extract the nectar from both petals. I think the double nectary is to favor bees, which are intelligent enough to drain both sides, while butterflies will probably leave one side full. This structure might also be of advantage in case of perforation, since the robber would have to make two holes or leave one side full. The double nectary, however, causes delay, and this seems to be the reason why the nectariferous petals of D. Consolida have developed a common cavity throughout.

D. tricorne agrees with the other species which have been studied in being male in the first stage and in being specially adapted to humble-bees.

The spurs of the petals from the point of insertion to the closed part measure from 7 to 9 mm., and to the tips from 15 to 17 mm., so that a proboscis 7 to 9 mm. long is needed to reach the nectar, and one 15 to 17 mm. long to exhaust it. Only the females of Bombus are flying while the plant blooms. B. Pennsylvanicus, with a tongue 16 to 17 mm. long, is best adapted to suck up all of the honey.

[4] Science Gossip, 1877, 249.

Müller found D. Consolida visited by Bombus hortorum and lapidarius. He also found butterflies, Satyrus and Hesperia, stealing honey, and I have found a still greater number on this plant. The presence of these insects on bee-flowers is always important, since it enables us to understand how many flowers which originally must have been adapted to bees have been modified to suit butterflies. The white-flowered form of this plant might easily become adapted to hawk moths.

Müller found D. elatum visited by Bombus hortorum and Anthophora personata.

On six days between May 4 and 13, I caught the following insects on the flowers. Nos. 4 and 6 are characteristic visitors, while 8–18 are intruders:

Hymenoptera—*Apidæ:* (1) *Bombus virginicus* Oliv. ♀; (2) *B. separatus* Cress. ♀ (11–13)[5]; (3) *B. vagans* Sm. ♀; (4) *B. pennsylvanicus* De G. ♀ (16–17); (5) *Anthophora abrupta* Say ♂ (14); all sucking; (6) *Synhalonia speciosa* Cress. ♂ ♀, s. and c. p.; (7) *S. atriventris* Sm. ♂, s.; (8) *Ceratina dulpa* Say ♀ (5–6) crawling into lower part of spur whence it may reach a little nectar. *Andrenidæ:* (9) *Agapostemon radiatus* Say ♀; (10) Halictus sp. ♀, both trying to collect pollen.

Lepidoptera—*Rhopalocera:* (11) *Danais archippus* F.; (12) *Papilio asterias* F.: (13) *P. troilus* L.; (14) *P. turnus* L.; (15) *Colias philodice* Godt.; (16) *Pamphila zabulon* Bd.-Lec.; (17) *Eudamus tityrus* F. *Sphingidæ:* (18) *Deilephila lineata* F.

Nuphar advena Ait.—On the first day the anthers are closed, and are crowded in a compact mass under the edges of the broad stigma. Their fleshy tips keep them from being gnawed by beetles. The petals also protect the lower anthers from gnawing-insects, and secrete nectar on their outer faces. At this time the stigma is receptive, and the flower is therefore proterogynous. The yellow sepals separate so as to leave a triangular opening over the stigma, so narrow that insects can not enter the flower without crawling over the stigmatic surface.

On the second and one or two succeeding days the anthers are dehiscent. The sepals then are often so widely separated that insects are no longer required to come in contact with the stigma.

[5] The numbers after an insect's name indicate the length of the proboscis in millimetres.

In Illinois in August, and in Florida in February, I found the flowers visited by the same species of insects, *Halictus* ~~*pectoralis* Sm.~~ nelumbonis ♀ (Andrenidæ), and *Helophilus divisus* Loew (Syrphidæ). In Florida I also found it visited by a fly, *Notiphila* sp. (Ephydridæ), and a beetle, *Donacia piscatrix* Lac. (Chrysomelidæ). The beetles were abundant on the older flowers, where they were pairing, the females gnawing the petals and anthers. I tried to catch the visitors by holding my net over the flowers and shaking the stalks, which only made the bees lie more closely, and for awhile I thought visitors were very scarce. Finally, I picked many flowers, and, bending back the sepals, found an Halictus under the petals of most of them, especially the new flowers. All of the bees taken on new flowers were well dusted with pollen from older flowers.

At Madison, Wisconsin, Prof. Trelease (MS. notes) also found it visited by Halictus ~~pectoralis~~ nelumbonis and Donacia piscatrix.

Sprengel (702) found N. luteum visited by beetles of the genus Meligethes. Müller also found it visited by Meligethes, and by Onesia floralis (Muscidæ) and Donacia dentata.

Delpino (178) regards N. luteum as adapted to beetles, but I find no evidence of such adaptation in N. advena; the beetles which occur I regard as worse than useless. However, beetles of the genus Donacia are very fond of the flowers of Nuphar, since they were observed on them by Müller in Germany, by Trelease in Wisconsin, and by me in Florida.

Figures of N. luteum in Hooker's edition of Le Maout and Decaisne's Botany, 208, and in Sprengel, Pl. XXIII, indicate fairly well the male stage of N. advena. I see nothing to lead insects to touch the stigma when the flower is so widely expanded. Indeed, Sprengel says: "Bei der Nymphæa hingegen ist es ein blotzer Zufall, das die Blumenkäfer den Antherenstaub auf das Stigma schleppen," and he regards this as an explanation of the large size of the stigma. Pollination seems so uncertain in such a flower as to incline one to doubt whether it is intended to occur when the flower is so widely expanded.

Nymphæa tuberosa Paine.—In Southern Illinois this plant blooms from May until October. The flowers open in the morning sun and close in the afternoon.

On the first day the flowers are not widely expanded, looking like buds at a distance, and the first stage is likely to be overlooked. The petals stand close together, leaving but

a narrow entrance. The stamens stand in a compact circle close to the petals, and the anthers are indehiscent. The filaments vary from the outer, which are long and broad, to the innermost, which are short and slender. The claw-like scales which surround the concave stigma form with it a little bowl, which holds a large drop of water. At this time the stigmatic papillæ are well developed, and the flower is evidently in the female stage.

On the second morning the water has disappeared from the stigmatic basin, and the papillæ look dry and shrivelled. The claw-like scales are curled in strongly over the stigma, and the inner stamens, which are now dehiscent, have fallen over it, so as completely to hide it. The outer stamens are turned outward, and the petals are widely expanded.

Of eight flowers which were marked, four opened on three days and four on four days. One of the latter had some anthers still closed at noon of the fourth day, promising to open again on the fifth. The flowers are therefore female on the first day and male for two or three days after. It follows that, when about the same number of new flowers open daily, there will be two or three times as many in the male as in the female stage.

All of the insects which I saw on the flowers were in search of pollen, which the numerous stamens yield in abundance. Insects coming from the old flowers drop into the new ones, and plunge into the stigmatic basin. If, in their attempts to escape, they trust their weight to the inner stamens, these bend so suddenly as to throw them again into the water. If the insect does not drop into the stigmatic basin, but lights on the stamens, the slender filaments act like the lip of Calopogon and let him down upon the stigma.

The water on the stigma seems to be intended to loosen the pollen from the scopæ of bees which have been collecting it on the older flowers. I have not discovered any sweet taste in the water, nor have I seen insects attracted by it. Moreover, it seems to be present in too great quantity for the purpose of nectar. Indeed, when insects are thrown back repeatedly into it, they may be drowned. I have seen Agapostemon radiatus and Halictus occcidentalis drowned in the same basin.[6]

If my interpretation is correct, the flower is remarkable

[6] A. Bacon (Torr. Bull. V, 51) found dead insects in flowers of N. odorata, which he supposes were captured by the flower closing up. Delpino (178) also found dead insects in N. alba, and considers their death as a result of the heavy odor of the flower. Planchon (Flore des serres et des jardins, 1850) thinks it a result of the accumulation of carbonic acid in the bottom of the flower

for having perfected a proterogynous condition, although visited exclusively for pollen. Even when nectar is present, many insects in search of pollen only visit dichogamous flowers in the male stage. We have observed that most of the flowers are discharging pollen, so that insects drop carelessly into them and are evidently surprised when they find themselves in the stigmatic basin of a new flower. Attracted by the abundant stamens, they do not discover their mistake before they touch the stigma. However, I have sometimes seen Halictus ~~pectoralis~~ turn away from a new flower into nelumbonis which it was about to drop, and fly to an old one.

On ten days between May 22 and September 18, I took the following insects on the flowers: Hymenoptera—*Andrenidæ:* (1) Agapostemon radiatus Say ♀, c. p., ab., sometimes drowned; (2) A. ~~nigricornis F.~~ ♀, c. p., ab.; (3–4) Halic- bicolor Rob. tus spp., ♀, c. p.; (5) H. ~~pectoralis Sm.~~ ♀, c. p., ab.; (6) nelumbonis H. occidentalis Cress. ♀, c. p., sometimes downed; (7) H. coriaceus Sm. ♀, c. p. do.; (8) Prosopis sp. ♀, e. p.

Diptera—*Syrphidæ:* (9) Helophilus divisus Lw. e. p., ab.; (10) H. latifrons Lw., e. p. *Bombylidæ:* (11) Sparnopolius fulvus Wied.

Coleoptera—*Rhipiphoridæ:* (12) Rhipiphorus limbatus F., drowned.

Nymphæa odorata L.—The flower resembles N. tuberosa, and is likewise female in the first stage. In Florida, in February, I have seen it visited by Halictus ~~pectoralis Sm.~~ ♀. nelumbonis

Delpino (178) regards Nymphæa as specially adapted to beetles. He states that Piccioli found N. alba abundantly visited by Donacia.

Dicentra Cucullaria DC.—The flower is figured and its mechanism described by Hildebrand (358). A peculiar interest surrounds it from the fact that its time of blooming is correlated with the appearance of long-tongued bees, and in my neighborhood it is the first flower adapted to them. In April, 1886, the first open flower was observed on the 7th, with no visitor. April 9, I found hive-bees collecting pollen and Papilio ajax sucking. April 11, hive-bees were collecting pollen, Bombylius, butterflies and the first humble-bees were sucking. On the 12th, humble-bees were present in considerable numbers for the first time, so that it required six days for the proper insect relations to become established.

The two inner petals are united over the anthers, protect-

7.

ing them from insects which are in search of pollen, so that the flowers are only adapted to be visited for honey. But the hive-bee visits the flower only for pollen, and I have seen no better illustration of its ingenuity than its success in gathering it. With its head it pushes aside the inner petals, partly separating them, while it removes the pollen with its front feet.

The pendulous position of the flowers makes them inconvenient for all visitors except bees (and Bombylius), but butterflies sometimes hang under the flowers and steal some of the nectar.

The nectar is secreted by two long processes of the middle stamens, and rises to the tip of the spur. A proboscis about 8 mm. long is necessary to reach it, and one 12½ to 14 mm. to obtain all of it. The females, which have longer tongues than the males and workers, are the only individuals of Bombus which fly while this plant is in bloom, and since the shortest-tongued of them can easily reach the nectar, it is strange that any should ever be guilty of cutting holes in the flowers. I have seen many individuals of four species sucking, but never perforating. However, the flowers are sometimes perforated by humble-bees (?), according to Leggett, Bailey, Stone and Merriam[7]. One observer states that humble-bees made the holes, and that honey-bees were sucking. The honey-bee's tongue is only 6 mm. long, and can hardly reach any of the nectar, and although I have seen this bee collecting pollen very often, I have never seen it sucking. His honey-bee was evidently a Synhalonia.

Observed on ten days, between April 9 and 30. Nos. 2–12 are proper visitors, the rest intruders. Hymenoptera–*Apidæ:* (1) Apis mellifica L. ☿, c. p.; (2) Bombus virginicus Oliv. ♀; (3) B. separatus Cress. ♀; (4) B. vagans Sm. ♀; (5) B. pennsylvanicus DeG. ♀: (6) Anthophora ursina Cress. ♂: (7) Habropoda floridana Sm. ♂; (8) Synhalonia atriventris Sm. ♂; (9) S. honesta Cress. ♂ ♀; (10) Osmia latitarsis Cress. ♂; (11) O. ~~montana Cress.~~ ♂; (12) O. lignaria Say ♂ ♀.

Diptera–*Bombylidæ:* (13) Bombylius fratellus Wied., sometimes on cold days the exclusive visitor.

Lepidotera–*Rhopalocera:* (14) Danais archippus F.; (15) Pyrameis atalanta L.: (16) Papilio ajax L.; (17) Pieris rapae L.; (18) Nisoniades martialis Scud., all sucking, except 1.

[7] See Pammel: Trans. St. Louis Acad. Sci., v. p. 274.

(11) O. simillima Sm.

9.

[From the BOTANICAL GAZETTE, Vol. xiv, No. 7.]

Flowers and Insects. II.

CHARLES ROBERTSON.[1]

Viola pubescens Ait. (fig. 1).—Müller regards the yellow violets as nearest the primitive type. This is yellow with dark nectar-lines. The petaline spur is little more than a gibbosity. The nectar-secreting processes of the lower stamens are very short, being much wider than long. The summit of the peduncle and the flower axis are strongly curved so as to throw the spur well backwards, giving the flower a characteristic appearance, and this serves to limit the insect visits much more than the mere length of the spur. The tips of the anthers and the style are closely approximated to the spurred petal and obstruct the entrance, so that insects unaccustomed to the flower are effectually baffled in their attempts to reach the nectar. The lateral petals are bearded.

FIGURE 1.

The stigma is nearer the anthers than in V. palmata and V. striata, and self-fertilization in case of insect-absence is more probable.

A proboscis 3 mm. long can secure the nectar, if the bee forces its head in as far as the anthers. Bees receive the pollen mainly on the under side of the head, and work it back into their scopæ, when collecting it. After visiting several flowers, Osmia settles upon a fallen leaf and applies the pollen to her ventral scopa, and then returns to the flowers.

After watching the flowers on six days, between April 16 and 30, I obtained only six visitors; but on April 20, 1889, in two hours watching I added twelve new names.

[1]On the fertilization of the genus see Müller: Fertilization of Flowers, 117–121 and 634.

Hymenoptera—*Apidæ:* (1) Anthophora ursina Cress. ♀. s., once; (2) Synhalonia honesta Cress. ♀, s., once: (3) Ceratina dupla Say ♀, s., once; (4) Osmia albiventris Cress. ♂ ♀ (=O. rustica Cress. ♂), s. and c. p., very ab.; (5) O. atriventris Cress. ♀, s. and c. p., ab.; (6) Nomada bisignata Say ♀, once. *Andrenidæ:* (7) Andrena sp. ♀, s. and c. p., once; (8) Augochlora pura Say ♀, s. and c. p., ab.; (9) Halictus coriaceus Sm. ♀ s.; (10) H. fasciatus Nyl. ♀, s; (11) H. pilosus Sm. ♀, s. and c. p.; (12) H. ~~connexus Cress.~~ ♀, s.; (13) H. stultus Cress. ♀, s. and c. p. confusus Sm.

Diptera—*Bombylidæ:* (14) Bombylius fratellus Wied., s., ab. *Tachinidæ:* (15) Gonia frontosa Say, s., once.

Lepidoptera—*Rhopalocera:* (16) Colias philodice Godt.; (17) Nisoniades juvenalis F.; (18) N. martialis Scud. All sucked in a reversed position, except nos. 1, 14 and 16–18. Paragus tibialis, Melanostoma obscurum and Mesograpta marginata (Syrphidæ) eat stray pollen.

Viola palmata L. var. *cucullata* Gray (fig. 2).—This is our common blue violet. The lateral petals are bearded. The stigma touches the bee in advance of the anthers, and cross-fertilization is the natural result of insect visits. The staminal processes measure 3mm. and the spur about 4mm. The nectar is more deeply concealed than in V. pubescens, and, as a consequence, the list shows more long tongues.

FIGURE 2.

Hymenoptera—*Apidæ:* (1) Apis mellifica L. ☿, once; (2) Bombus separatus Cress. ♀; (3) B. pennsylvanicus De G. ♀; (4) Synhalonia speciosa Cress. ♂; (5) S. honesta Cress. ♀; (6) Ceratina dupla Say ♀, all sucking; (7) Osmia albiventris Cress. ♂ ♀, s. and c. p., ab.; (8) O. atriventris Cress ♀. s. and c. p., ab.; (9) Nomada vincta Say ♀, s. *Andrenidæ:* (10) Andrena sp. ♂ ♀, s. and c. p., ab.; (11) Halictus sp. ♀, s.: (12) H. fasciatus Nyl. ♀, s.

Diptera—*Bombylidæ*: (13) Bombylius fratellus Wied., s.

Lepidoptera—*Rhopalocera:* (14) Pyrameis huntera F.: (15) Colias philodice Godt.; (16) Pieris rapæ L.; (17) Nisoniades juvenalis F.; (18) N. martialis Scud. All sucked head downwards except nos. 6, 11 and 13; nos. 14–18 sometimes upright, sometimes reversing. Observed on nine days, between April 9 and 29.

11.

Viola striata Ait. (fig. 3).—The flower is yellowish white, a few purplish lines on the lower petal forming nectar-guides. The lateral petals are bearded. The stigma is far in advance of the anthers, so that self-pollination is prevented. The spur is considerably longer than in V. palmata. On three days, between April 16 and May 4, I observed only:

FIGURE 3.

Hymenoptera—*Apidæ:* (1) Synhalonia honesta Cress. ♂, s.; (2) Osmia albiventris Cress. ♀, s. and c. p., ab.; (3) O. atriventris Cress. ♀, s.; (4) O. brevis ~~montana~~ Cress. ♀, s. and c. p. *Andrenidæ:* (5) Andrena sp. ♀, s.; (6) Halictus coriaceus Sm. ♀, s. and c. p.

Diptera—*Bombylidæ;* (7) Bombylius fratellus Wied. s.

Lepidoptera—*Rhopalocera:* (8) Colias philodice Godt.—all reversing except nos. 1, 7 and 8.

Viola pedata L. var. *bicolor* Gray (fig. 4).—The flowers are larger than in any of the preceding species. The two upper petals are of a deep purple, the others blue, the handsome flowers bearing a resemblance to the pansy. The lateral petals are not bearded. The lower petal is deeply grooved and is produced behind into a curved spur from 4 to 8 mm. long. The strong style and the anthers project considerably and oppose the way to the nectar, so that the extent of concealment of the nectar is determined by the distance from the tip of the style to the tip of the spur—a distance of from 12 to 16 mm. The staminal spurs are about 4 mm. long and are very slender. The spur of the lower petal is slender and strongly compressed so as to narrow its cavity. As might be expected, the visitors are the longest-tongued bees, though butterflies often occur. The pollen is shed on the base of the proboscis of the insect.

FIGURE 4.

Hymenoptera—*Apidæ:* (1) Bombus virginicus Oliv. ♀ (14)[2]; (2) B. separatus Cress. ♀ (11–13); (3) B. ~~pennsyl-~~

[2]Numbers in parenthesis after the name of the bee indicate the length of the proboscis in mm.

(3) B. americanorum F.

vanicus DeG. ♀ (16–17), ab.; (4) Anthophora ursina Cress. ♀ (18), s. & c. p., ab.; (5) Synhalonia speciosa Cress ♂ ♀ (13–15), all sucking in an upright position.

Lepidoptera—*Rhopalocera:* (6) Pyrameis cardui L., once, reversing; (7) Colias philodice Godt., sometimes reversing; (8) Nisoniades icelus Lintn., ab.; (9) N. juvenalis F., both always reversing. *Noctuidæ:* (10) Plusia simplex Guen., once, not reversing. On four days, between April 28 and May 3.

Eristalis latifrons eats stray pollen which falls upon lower petal.

Viola lanceolata L.—At Orlando, Fla., Feb. 17, I found it visited by Hymenoptera—*Andrenidæ:* (1) Halictus capitosus Sm. ♀, s. Lepidoptera—*Rhopalocera:* (2) Phyciodes tharos Dru.; (3) Pamphila sp.

General notes on the forfgoing violets.—In a paper on the cause of floral irregularity,[3] Viola was mentioned as an exception to the rule that irregular polypetalous flowers have the nectary on the upper side. I think the spur was developed in a way analogous to the galea of Aconitum, *i. e.* on the upper side of the flower, and that it has changed to the lower side as a result of inversion of the flower. The weight of the spur itself may have had something to do with turning the flower upside down. Not only would the flower be expected to have been originally sternotribe from my theory, but it is still properly so, for in most cases it is so formed that bees are required to turn upside down to reach the nectar. Fig. XI of the title page of Sprengel's "Entdeckte Geheimniss" shows a flower of V. odorata with a hive-bee sucking in a reversed position. The spur seems to have become so closely fitted to the bee that after inversion the bee was forced to turn head downwards in order to extract the sweets.

On the part of the flower, the resupinate position seems to be advantageous in enabling it to sift the pollen down upon the insect, instead of exposing it to pollen-eating intruders. Under V. tricolor, Müller says: "The anthers, which together form a cone, shed their pollen into this groove (*i. e.* of the lower petal), either of themselves or when the pistil is shaken by the insertion of the bee's proboscis." It seems to me that the action to which the mechanism is adapted to give

[3] Bot. Gaz., XIII., 207.

rise, and the only action which will insure that the pollen shall be applied to the same side of the proboscis which touches the stigma, is that the pollen discharge shall be effected by the bee itself.

On the part of the visitors, the inversion seems particularly favorable to bees of the genus Osmia, and I am inclined to consider the flowers of V. pubescens, palmata and striata as specially adapted to them, in spite of the presence of other visitors. Now, these bees have their pollen-collecting hairs situated on the ventral surface of the abdomen, so that the position which they must take to suck is the one which enables them to receive the pollen and apply it to their scopæ most conveniently. For this reason, species of Osmia are the most abundant and most useful visitors. Indeed, for the species referred to, I am convinced that Osmia albiventris and atriventris are of more importance than all of the other visitors put together. Müller mentions bees of this genus as visitors of V. odorata, canina and tricolor, var. arvensis.

Delpino (178)[4] has discovered that the beards on the lateral petals are intended for the bee to cling to when it turns head downwards. He rightly regards the bees which reverse as legitimate visitors, and considers the action of Anthophora pilipes on V. tricolor as illegitimate, since it inserts its proboscis without turning. Really, the proper visitors are bees which are small enough to use the beard as a support; so that the humble-bees and butterflies may properly be classed as intruders, even when they reverse. For the proper visitors of the bearded violets we must look to small bees, among which the Osmias are most important.

Remembering that the bearded violets are sternotribe, it is interesting to observe that they become nototribe with respect to all visitors, like Anthophora and Bombylius, which fail to reverse, and this enables us to understand how a properly nototribe violet might be produced. V. pedata is a violet of this sort, being visited mainly by long-tongued bees, which light upon the spurred petal and remain upright. The lateral petals have lost their beards, since they are no longer of use to the bees. The flower still retains the upward curvature of the spur as an ancestral characer. If the spur had been developed with reference to visitors acting like most of those now seeking it, I think it would curve down rather

[4] Numbers in parenthesis after an author's name are the numbers of titles in Thompson's Bibliography. See Müller: Fertilization of Flowers, pp. 599-634.

than up. The effect of the upward curvature of the spur is well illustrated in the behavior of Nisoniades, which invariably turn head downwards.

It has often occurred to me that Bombylius could suck the bearded violets more easily than the insects which reverse, and that under certain conditions it might take possession of them, as Anthophora and Bombus have done in the case of V. pedata. In this connection, it is interesting to refer to Müller's observations on V. calcarata. He saw Macroglossa stellatarum visit 194 flowers of this violet in $6\frac{3}{4}$ minutes. So rapid a visitor might easily take possession of any flower which suits its fancy. V. calcarata appears to have become completely adjusted to a new set of conditions, for its spur, as shown in Müller's figures, turns downward, and not upwards as in V. pedata.

Claytonia Virginica L.—The proterandry of this flower was first recorded by Bessey (87). He concludes that the adaptations are to favor cross-fertilization and to prevent self-fertilization, and my observations confirm his view. On the other hand, Meehan, in a paper on "The 'Sleep of Plants' as an Agent in Self-fertilization" (485), regards it as commonly self-fertilized by closing of the petals. This mode of self-fertilization was discussed by Ch. Fermond[5] in 1859, but C. Virginica is a very poor example of it. Indeed, it is most erroneous to suppose that it is commonly self-fertilized in this way, for it is one of the most marked cases of proterandry in native plants.

On the first day the stamens stand in the center of the flower and the anthers discharge their pollen, but the lobes of the stigma remain closed. The flower is visited very abundantly by insects which suck up the honey and which eat or collect the pollen, so that by the time the flower closes the pollen is commonly all removed. On the second day the stamens are bent over, holding the empty anthers against the petals. The stigma lobes are now separated, and the flower is in the second or female stage. If self-fertilization by closing of the flower occurs, it is after the anthers have been exposed to insects for two days and the stigma for one, but many flowers which I marked exposed their stigmas again on the third day, showing that fertilization of any kind had failed on the day before. The flowers are therefore male on the first day and female on the second and sometimes on the third.

[5] See Just's Bot. Jahresbericht, IV, 939.

15

Moreover, Meehan states that he did not see the flowers visited by insects—an observation easy to make on any flower. The plants grow in large patches and are very attractive to a great variety of insects. The nectar is not deep seated, so that rather short tongues can reach it. On 26 days, between April 8 and May 11, the following visitors were observed:

Hymenoptera—*Apidæ:* (1) Apis mellifica L. ☿, s. and c. p.; (2) Bombus virginicus Oliv. ♀; (3) B. vagans Sm. ♀; (4) B. pennsylvanicus DeG. ♀; (5) Synhalonia honesta Cress. ♂; (6) S. speciosa Cress. ♀; (7) Ceratina dupla Say ♂; (8) Osmia lignaria Say ♂ ♀; (9) O. albiventris Cress. ♂ ♀; (10) Nomada bisignata Say ♀; (11) N. luteola St. Farg. ♂ ♀, all only sucking, except no. 1. *Andrenidæ:* (12–20) Andrena spp., s. and c. p., ab.; (21) Agapostemon radiatus Say ♀, s. and c. p.; (22) Augochlora pura Say ♀, s.; (23) A. lucidula Sm. ♀, s.; (24) Halictus sp. ♀, s. and c. p.; (25) H. coriaceus Sm. ♀, do.; (26) H. fasciatus Nyl? ♀, do.; (27) H. pilosus Sm. ♀, do,; (28) H. ~~connexus Cress~~. ♀, do.; (29) Colletes inæqualis Say ♂ ♀, s. confusus Sm.

Diptera—*Stratiomyidæ:* (30) Sargus viridis Say. *Bombylidæ:* (31) Bombylius fratellus Wied., s. *Conopidæ:* (32) Myopa vesiculosa Say, s. *Empidæ:* (33–35) Empis spp. s. *Syrphidæ:* (36) Melanostoma obscurum Say; (37) Syrphus arcuatus Fall.; (38) S. ribesii F.; (39) S. americanus Wied.; (40) Allograpta obliqua Say; (41) Mesograpta marginata Say; (42) M. geminata Say; (43) Sphærophoria cylindrica Say; (44) Eristalis dimidiatus Wied.; (45) E. latifrons Lw.; (46) Helophilus similis Macq.; (47) Syritta pipiens L.—all sucking and feeding on pollen. *Tachinidæ:* (48) Gonia frontosa Say, s. *Sarcophagidæ:* (49) sp., s.; (50, 51) Sarcophaga spp., s. *Muscidiæ:* (52) Lucilia cæsar L.; (53) L. cornicina Mgn.; (54) ~~L. ruficeps~~ Mgn., all s. *Anthomyidæ:* (55–57) spp., s. *Cordyluridæ:* (58) Scatophaga squalida Mgn., s. *Sepsidæ:* (59) Sepsis sp. *Drosophilidæ:* (60) Drosophila sp.

Lepidoptera—*Rhopalocera:* (61) Phyciodes tharos Dur.; (62) Pyrameis atalanta L.; (63) Lycæna comyntas Godt.; (64) Papilio ajax L.; (65) Pieris protodice Bd.-Lec.; (66) P. rapæ L.; (67) Colias philodice Godt.; (68) Nisoniades icelus Lintn.; (69) N. juvenalis F.—all s.

Coleoptera—~~*Chrysomelidæ*~~: (70) Megilla maculata DeG. *Curculionidæ:* (71) Centrinus sp.

Carlinville, Ill.

Coccinellidae:

(54) Calliphora erythrocephala

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Flowers and Insects. III.

CHARLES ROBERTSON.

Nelumbo[1] *lutea* Planch.—The flowers are female in the first stage. On the first day the petals separate at tips, so that insects can enter and crawl about upon the carpophore and over the stigmas. At this time the anthers are indehiscent and are pressed close against the sides of the carpophore, being held in this position by the erect petals. The claw-like tips of the anthers, the only parts of the stamens now visible, form a close circle between the petals and the edge of the carpophore, thus opposing insects which might attempt to reach the pollen.

On the second day, when the petals begin to separate, insects can only reach the anthers, which are now discharging pollen, by crawling over the stigmas. Later, when the petals become widely expanded and the anthers fall upon them, insects no longer light upon the carpophore.

Delpino regards flowers of this genus as specially adapted to beetles which he supposes visit the flowers to gnaw the carpophore. I have never seen them eating this part, nor are they sufficiently abundant on the flowers to be of much use. Moreover, they remain almost stationary and seldom fly from flower to flower. Delpino has classed the flowers of Nymphæaceæ in general as *cantharophilous*, it seems to me without enough evidence. I have found Nymphæa[2] and Nelumbo visited only for pollen and Nuphar[2] both for pollen and nectar. The principal visitors are Andrenidæ, especially species of Halictus, and Syrphidæ.

Visitors (observed on 3 days between July 26 and August 12): Hymenoptera—*Apidæ:* (1) *Apis mellifica* L. ☿, c. p., ab.: (2) *Ceratina dupla* Say ♀. *Andrenidæ:* (3) *Agapostemon radiatus* Say ♀, ab.; (4) *Augochlora pura* Say ♀, ab.: (5, 6) Halictus spp. ♀, ab.; (7) *H. ligatus* Say ♀; (8) *H. Lerouxii* St. Farg. ♀ (= *parallelus* Sm.); (9) *H. parallelus* Say ♀, ab. (= *occidentalis* Cr.); (10) *H. pilosus* Sm. ♀, ab.: (11) *H. confusus* Sm. ♀, ab., all c. p.; (12) Prosopis

[1] On the fertilization of Nelumbo see Delpino: Ulteriori osservazioni sulla dicogamia nel regno vegetale; and Comes: Studii sulla impollinagione in alcune piante.

[2] Bot. Gazette. XIV, 122–125.

sp. ♀; (13) *P. affinis* Sm. ♀, both f. p. *Scoliidæ:* (14) *Myzine interrupta* Say; (15) *Scolia bicincta* F.

Diptera—*Syrphidæ:* (16) *Pipiza pullchella* Will. ab.; (17) *Chrysogaster nitida* Wied.; (18) *Syrphus ribesii* L.: (19) *Mesograpta marginata* Say; (20) *Sphærophoria cylindrica* Say; (21) *Syritta pipiens* L., all f. p. *Ephydridæ:* (22) *Notiphila unicolor* Lw., f. p.

Coleoptera—*Coccinellidæ:* (23) *Megilla maculata* De G.; (24) *Hippodamea 13-punctata* L. *Cerambycidæ.* (25) *Leptura plebeja* Rand. *Chrysomelidæ:* (26) *Diabrotica 12-punctata* F., ab., all f. p.

Workers of Bombus separatus, B. americanorum[3] and B. scutellaris dropped into the flowers, but immediately flew away, as if they had failed to find what they sought. I also found Bombus virginicus, Agapostemon radiatus and Lucilia cornicina dead in the flowers, where they had probably been enclosed by the petals and suffocated by the heavy odor.[4]

Dentaria laciniata Muhl.—This flower agrees in most respects with Cardamine pratensis, as described by Müller. But the nectaries which occupy the position of the two missing stamens are of nearly or quite the same importance as those surrounding the bases of the two short stamens. Accordingly the saccate bases of the sepals which hold the nectar from these glands are of about the same size as the others. The stigma commonly surpasses the anthers, so that it strikes the bee in advance of them, but there is a chance of self-pollination in absence of insects.

The erect sepals and the claws of the petals measure about 8 mm., and with the stamens and style narrow all ways of access to the nectar, so that only insects with a tongue 8 mm., or longer, can reach the nectar with perfect ease. But short-tongued bees sometimes manage to force their way in so as to reach the sweets. The flowers are white, or sometimes with a purplish tinge, and grow in rather conspicuous umbels. There are more long-tongued bees than in Müller's list of visitors of C. pratensis.

Visitors (observed on 7 days, between April 2 and 20):

[3] *Bombus americanorum* Fabr. is our common bumble bee. For a long time it has been mixed up with *B. pennsylvanicus* De Geer, but it is a distinct species, and *B. elatus* Fabr. (Apathus? elatus) is its male. I have taken the sexes of B. pennsylvanicus in copula. I have also taken B. elatus in copula with B. americanorum. Three nests of the latter which I opened contained no male bees except B. elatus. The nest mentioned in Proc. Ent. Soc. Phil., II, 164, said to contain 6 females and 34 workers of B. pennsylvanicus and 21 males of Apathus elatus, must have belonged to B. americanorum.

[4] Delpino mentions that insects are so killed in flowers of N. speciosa.

Hymenoptera—*Apidæ:* (1) *Apis mellifica* L., s. and c. p.; (2) *Bombus separatus* Cr. ♀, s.; (3) *B. virginicus* Oliv. ♀, s.; (4) *B. americanorum* F. ♀, s.; (5) *Synhalonia honesta* Cr. ♂ ♀, s.; (6) *Ceratina dupla* Say ♂ s.; (7) *Osmia lignaria* Say ♂, s.; (8) Nomada sp. ♀, s. *Andrenidæ:* (9–11) Andrena spp. ♂ ♀, s.; (12) Halictus sp. ♀, s.; (13) *H. confusus* Sm. ♀, s.; (14) *H. stultus* Cr. ♀, c. p.

Diptera—*Bombylidæ:* (15) *Bombylius fratellus* Wied. s. *Syrphidæ:* (16) *Syrphus ribesii* F.; (17) *Sphærophoria cylindrica* Say, both f. p.

Lepidoptera—*Rhopalocera:* (18) *Lycæna comyntas* Godt.; (19) *Papilio ajax* L.

At Madison, Wis., in May, Prof. Trelease found it visited by Ceratina dupla, Osmia albiventris, ♂, and Pieris rapæ.

Geranium maculatum L.[5]—The flower agrees with the larger flowered species (G. palustre and pratense) described by Müller. The five outer stamens discharge their pollen over the center of the flower, and afterwards the five inner do the same. The anthers commonly fall off before the stigma is receptive, and the power of self-fertilization is lost. I have observed that the flowers change slowly in bad weather; some of them are in the male stage for three days and others in the female stage for as long. But on warm fair days they go through both stages on the same day.

Some small insects light upon the petals and are able to reach the nectar, though they are of doubtful value, since they are by no means certain to touch the anthers and stigmas. Müller found species of Halictus especially numerous on G. palustre, and I have found several species of Andrenidæ on this plant; but the larger bees seem to be more useful.

Visitors (observed on seven days between May 1 and 21): Hymenoptera—*Apidæ:* (1) *Apis mellifica* L. ☿; (2) *Bombus vagans* Sm. ♀; (3) *B. americanorum* F. ♀; (4) *Synhalonia speciosa* Cr. ♀; (5) *Ceratina dupla* Say ♀; (6) *Osmia ~~montana~~* Cr. ♂. *Andrenidæ:* (7–9) Andrena spp. ♂ ♀, cognata
s. and c. p.; (10) *Augocholora pura* Say ♀; (11) *Halictus coriaceus* Sm. ♀; (12) *H. pilosus* Sm. ♀; (13) *H. confusus* Sm. ♀.

Diptera—*Empidæ:* (14) *Empis labiata* Lw. *Syrphidæ:* (15) *Helophilus latifrons* Lw., f. p.

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[5] See Macloskie: Bot. Gaz., IX, 157. For references to literature of pollination of Geraniaceæ see Trelease; North Am. Geraniaceæ, Mem. Bost. Soc. Nat. Hist., IV, 101. For illustration of this species see Goodale: Wild Fls., Pl. III.

Lepidoptera—*Rhopalocera:* (16) *Colias philodice* Godt. *Sphingidæ:* (17) *Hemaris thysbe* F.—all only sucking except 7–9 and 15.

At Madison, Wis., between May 13 and June 1, Prof. Trelease found as visitors: *Nomada bisignata* Say, *N. articulata* Sm., *Augochlora pura* Say, and Andrena sp., all sucking.

Impatiens[6] *fulva* Nutt.—The flowers of this species, and of the next, are male in the first stage as is well known. The anthers sift out a great quantity of pollen when struck by a bee, and the stigma is receptive after the anthers fall. Compared with I. pallida this plant shows three peculiarities which I think favor humming-birds, viz., the red color, the small landing-place, and the longer and narrower posterior sepal. The landing is about 6 mm. long and 15 mm. wide, while in I. pallida it is 12 mm. long and 25 mm. wide and forms a more convenient resting place for bees. However, the form of I. fulva so closely resembles that of I. noli-tangere, which was developed beyond the range of humming-birds, that it can hardly be explained as a result of bird selection. It originally must have had differences which led the birds to prefer it to I. pallida. There is one peculiarity, however, which may have been produced through the influence of birds, and that is the accumulation of red spots on the original ground color. I have elsewhere expressed the view that irregular bird-flowers were originally modified by bees[7] and have been usurped by birds. From its color, and from the fact that humming-birds are the principal visitors, I regard it as a bird-flower, although bees and butterflies also occur as guests.

The posterior sepal is about 22 mm. long, and its spur, which is commonly coiled upon itself, is about 10 mm.

Visitors: Birds—*Trochilidæ:* (1) *Trochilus colubris* L., ab.

Hymenoptera—*Apidæ:* (2) *Apis mellifica* L. ☿, s. and c. p. Snyder's[8] statement that it can not effect crossing is not true in my neighborhood; (3) *Bombus virginicus* Oliv. ☿, s. and c. p.; (4) *B. americanorum* F. ♂ ☿, s.; (5) *Melissodes bimaculata* Say ♀, s.; (6) *Megachile brevis* Say ♀, c. p., hangs under the anthers so as to bring her abdominal scopa in con-

[6] On the literature of the genus see Trelease: l. c., 102.

[7] Bot. Gaz. xiii. 228.

[8] Am. Nat. xiv. 126.

tact with them and only visits flowers in the male stage. *Andrenidæ:* (7) *Augochlora pura* Say ♀, c. p., works out the pollen with her jaws and front feet, not touching stigma; (8) *Halictus confusus* Sm. ♀, c. p., like no. 7.

Lepidoptera—*Rhopalocera:* (9) *Papilio troilus* L. s.

Coleoptera—*Chrysomelidæ:* (10) *Diabrotica 12-punctata* F., gnaws holes in spurred sepal.[9]

Nos. 1–5 and 8 are useful visitors, while the rest are not. Differences in the pollen-collecting habits of Bombus and Megachile are well illustrated in this case. The former receives pollen on the dorsal surface of her thorax and wipes it off with her front legs to place it in her baskets, the latter turns so as to receive it directly in her scopa. Small species of Halictus commonly visit flowers adapted to larger insects to collect pollen directly from the anthers or to glean stray grains which are scattered about the flower. In the latter case they do no harm. The Syrphidæ also often act as gleaners of stray pollen, and only do harm when they eat it directly from the anthers.

Pollen-gathering is illegitimate behavior in this flower, since it leads the bees to pay more attention to the flowers which are in the male stage. When 2 and 3 are after pollen they neglect flowers in the second stage, since they instantly perceive that the anthers have fallen. The humming-bird coming only for nectar, and being the most rapid flier, is by far the most useful visitor, and it is but natural that it should have most influence in modifying the flower.

Impatiens pallida Nutt.—The flower is "pale-yellow, sparingly dotted with brownish red." It is much larger than in I. fulva, and has a shorter (13 mm.) and broader posterior sepal and a large horizontal landing—characters which favor humble-bees. The incurved spur measures about 6 mm. Humble-bees are more abundant and more constant in their visits than in I. fulva, while humming-birds were not seen visiting the flower.

Visitors: Hymenoptera—*Apidæ:* (1) *Bombus virginicus* Oliv. ☿, s. and c. p., ab.; (2) *B. americanorum* F. ♂, s. ab.: (3) *Megachile brevis* Say ♀, c. p., behaves as with I. fulva. *Andrenidæ:* (4) Halictus sp., s., not touching anthers and stigmas.

Diptera—*Syrphidæ:* (5) *Rhingia nasica* Say, s. and f. p.,

[9] Mutilation or perforation of the flowers of this species was recorded by Bailey: Torrey Bull. vi. 173; Trelease: ibid vii. 20; Van Ingen: Bot. Gaz. xii. 229.

not touching anthers when sucking. Several species of Syrphidæ eat pollen which is scattered on landing. Only nos. 1 and 2 are useful visitors.

Staphylea trifolia L.—Prof. W. J. Beal[10] examined the flowers of this plant and concluded "that the chances are better for cross-fertilization than otherwise." But Mr. Meehan[11] has interpreted it as adapted to self-fertilization. On the other hand, Dr. Gray[12] held that the flower is proterogynous and cross-fertilized by bees, and my observations led me to the same conclusion, while still unaware of his view. I find from Prof. Trelease's notes that he too regarded the flower as proterogynous. Newly opened flowers show a broad, three-lobed stigma nearly closing the entrance, and the still indehiscent anthers crowded under it. The surface of the stigma is always in advance of the anthers, and can hardly become thoroughly dusted with their pollen, even if it can receive enough for self-fertilization. The most that can be said is that the flower is self-fertilized in absence of insects—a very different thing from saying that it is adapted to self-fertilization. But the small number of fruit compared with the number of flowers leads me to doubt whether self-fertilization occurs, even when insects fail. Nectar is secreted by the disk surrounding the base of the ovary. The pendulous flower is about 6 mm. deep and the sepals and petals are erect and closely approximated, so that the flower has much the same form as in the gamopetalous genus Gaylussacia and has a like effect in excluding insects, although the petals are more yielding. The ovary, filaments and petals within are very hairy, and this also aids in making the honey less accessible to short tongues and in excluding small intruders. The flower thus favors long-tongued bees, although shorter-tongued insects sometimes succeed in forcing their way into the flowers far enough to reach the nectar.

Visitors (observed in five days, between April 23 and May 11): Hymenoptera—*Apidæ:* (1) *Apis mellifica* L. ☿, s. c. p., ab.; (2) *Bombus virginicus* Oliv. ♀; (3) *B. vagans* Sm. ♀; (4) *B. americanorum* F. ♀—all 3 s., ab. *Andrenidæ:* (5–8) Andrena spp. ♂ ♀, s. and c. p., ab.; (9) Halictus sp. ♀, s.; (10) *H. coriaceus* Sm. ♀, s.; (11) *Colletes inæqualis* Say ♂, s. *Vespidæ:* (12) *Vespa maculata* L. s.

[10]Am. Naturalist i. 258.

[11]Proc. Acad. Nat. Sci. Phila., 1876, 108.

[12]See Just's Bot. Jahresbericht iv. 939.

Diptera—*Empidæ:* (13) Empis sp., s. *Syrphidæ:* (14) *Eristalis flavipes* Walk., f. p.

Lepidoptera—*Rhopalocera:* (15) *Nisoniades juvenalis* F. s.

Coleoptera—*Scarabaeidæ:* (16) *Euphoria sepulchralis* F. f. p.

Ceanothus Americanus L.—The flowers and their pedicels are white. The stems are surmounted by many umbel-like clusters of flowers, and many stems are crowded together; so that insects are attracted for a considerable distance by what seems one large bunch of white flowers. Each hood of a petal encloses an anther, and the petal and stamen rise together. The peculiar form of the petals is associated with a peculiar disposition of the sepals, which serve to conceal the nectar, so as to limit the visitors to a more diligent set than would predominate if the nectar were more freely exposed. The nectar is secreted on a broad disk which is concealed by the sepals remaining strongly closed over it. A petal and an anther have thus to be liberated through the narrow slit between two sepals, and the form of the blade of the petal is to allow it to escape and to free the anther with it. In character of visitors the plant resembles those Umbelliferæ in which the disk is covered by the incurved petals.

Visitors (observed on five days between June 19 and 29): Hymenoptera—*Apidæ:* (1) *Bombus separatus* Cr. ♀, s. and c. p.; (2) *B. pennsylvanicus* DeG. ♀, c. p.; (3) *Ceratina dupla* Say ♂, s.; (4) *Megachile brevis* Say ♀, s. and c. p.; (5) *Heriades carinatum* Cr. ♀, s. and c. p.; (6) *Nomada incerta* Cr. ♀, s.; (7) *Calliopsis andreniformis* Sm. ♂, s. *Andrenidæ:* (8) Macropis sp. ♂, s.; (9) *Augochlora pura* Say ♀. s. and c. p.; (10) *Halictus pectoralis* Sm. ♀, s. and c. p.; (11) *H. similis* Sm. ♀, s. and c. p.; (12) *H. flavipes* F. ♀, s. and c. p,; (13) *H. confusus* Sm. ♀, s. and c. p.; (14) *H. stultus* Cr. ♀, s. and c. p.; (15) *Sphecodes confertus* Say ? ♂, ♀ s.; (16) *Prosopis affinis* Sm. ♂ ♀, s.; (17) *P. pygmaea* Cr. ♂ ♀, s. *Vespidæ:* (18) *Polistes pallipes* St. Farg. *Eumenidæ:* (19) *Eumenes fraternus* Say; (20) *Odynerus tigris* Sauss.; (21) *O. fulvipes* Sauss.; (22) *O. dorsalis* F.; (23) *O. foraminatus* Sauss.; (24) *O. conformis* Sauss.; (25) *O. pedestris* Sauss.; (26) *O. pennsylvanicus* Sauss. *Crabronidæ:* (27) *Crabro interruptus* St. Farg.; (28) *Oxybelus 4-notatus* Say; (29) *O. frontalis* Rob.; (30) *O. emarginatus* Say. *Philanthidæ:* (31, 32) Cerceris spp.; (33) *C. clypeata* Dahlb.; (34) *C. compacta* Cr.: (35) *C. compar* Cr.; (36) *C. rufinoda* Cr.

Larridæ: (37) *Larra acuta* Patton. *Sphecidæ:* (38) *Ammophila intercepta* St. Farg.; (39) *Pelopœus cementarius* Dru.; (40) *Isodontia philadelphica* St. Farg. *Pompilidæ:* (41, 42) Pompilus spp.; (43) *P. tenebrosus* Cr.; (44) *P. marginatus* Say; (45) *P. navus* Cr. *Chrysididæ:* (46) *Hedychrum violaceum* Brullé. *Chalcididæ:* (47) *Leucospis affinis* Say. *Tenthredinidæ:* (48) ~~Atomacera sp.~~—all s. except no. 2.

Diptera—*Chironomidæ:* (49) Ceratopogon sp., f. p. *Mycetophilidæ:* (50) Sciara sp. *Culicidæ:* (51) sp. *Stratiomyidæ:* (52) Pachygaster sp. *Empidæ:* (53) Empis sp. *Syrphidæ:* (54) *Paragus bicolor* F.; (55) *Chrysogaster nitida* Wied.; (56) *Syrphus americanus* Wied.; (57) *Allograpta obliqua* Say; (58) *Mesograpta geminata* Say; (59) *M. marginata* Say; (60) *Sphærophoria cylindrica* Say; (61) *Tropidia mamillata* Lw.; (62) *T. quadrata* Say; (63) *Syritta pipiens* L. *Conopidæ:* (64) *Conops brachyrrhynchus* Macq.; (65) *Zodion fulvifrons* Say; (66) *Oncomyia loraria* Lw. *Tachinidæ:* (67, 68) spp.; (69) Hyalomyia sp.; (70) *Cistogaster divisa* Lw.; (71, 72) Ocyptera spp.; (73) *Jurinia smaragdina* Macq.; (74) *J. apicifera* Walk.; (75) *Cyphocera ruficauda v. d.* Wulp.; (76) Micropalpus sp.; (77) Exorista sp.; (78) Eggeria? sp.; (79) *Acroglossa hesperidarum* Will? *Sarcophagidæ:* (80, 81) Sarcophaga spp. Muscidæ: (82) sp.; (83) *Musca domestica* L.; (84) Lucilia, sp.; (85) *L. cæsar* L.; (86) *L. cornicina* F. *Anthomyidæ:* (87) Anthomyia sp.; (88) Limnophora sp. *Trypetidæ:* (89) *Trypeta humilis* Lw? *Sepsidæ:* (90) Sepsis sp. *Oscinidæ:* (91, 92) spp.; (93) Oscinis sp.—all s. or f. p.

Coleoptera—*Dermestidæ:* (94) *Cryptorhopalum hæmorrhoidale* Lec. *Elateridæ:* (95) *Limonius griseus* Beauv. *Lampyridæ:* (96) *Telephorus scitulus* Say. *Scarabæidæ:* (97) *Trichius piger* F. *Cerambycidæ:* (98) *Typocerus sinuatus* Newm. *Chrysomelidæ:* (99) *Pachybrachys atomarius* Melsh.; (100) *Diabrotica 12-punctata* F.; (101) *D. atripennis* Say. *Œdemeridæ:* (102) *Oxacis thoracica* F. *Mordellidæ:* (103) *Mordella marginata* Melsh. *Curculionidæ:* (104) Centrinus sp.; (105) *C. scutellum album* Say; (106) *C. picumnus* Hbst.

Hemiptera—*Capsidæ:* (107) *Calocoris rapidus* Say; (108) *Lygus pratensis* L. *Lygæidæ:* (109) *Lygæus turcicus* F. *Cydnidæ:* (110) *Canthophorus cinctus* P. B.—all s.

Lepidoptera—*Rhopalocera:* (111) *Thecla acadica* Edw.; (112) *T. calanus* Hübn.

Carlinville, Ill.

(48) Hylotoma humeralis Bv.

VOL. XV. NO. 4.—BOTANICAL GAZETTE.—APR., 1890.

Flowers and insects. IV.

CHARLES ROBERTSON.

Baptisia leucantha Torr. & Gr.—The flowers are arranged in long, loose, erect racemes, and are white, except a broad purple streak on the base of the banner, which forms a nectar-guide. The stamens are distinct, and bees insert their proboscides between the filaments of the upper ones. The anthers dehisce in succession. Accordingly bees visit each flower several times to gather the pollen. After the wings and keel have been depressed by an insect resting upon them, they promptly return to their former position, concealing the stamens and pistil.

The calyx is from 8 to 9 mm. deep, which alone would restrict the visitors to the longest tongues. The calyx further tends to exclude short tongues by clasping the petals and holding them so that they are not easily forced apart. Then the banner is strengthened by three longitudinal folds —a median one where it clasps the wing and keel petals, and two lateral ones formed by the lobes being reflexed upon the central portion. The banner thus forcibly resists any upward pressure. On account of the depth of the calyx and the large size and rigidity of the petals, only the largest and strongest bees can force their way in. The flowers are visited very abundantly for honey and pollen by *Bombus americanorum* F. ☿. I know of no other flower in my neighborhood which seems to depend so exclusively on a single species of humble bee. Once I saw a butterfly, *Callidryas eubule* L., thrusting its proboscis under the banner, but, although it could reach the nectar, it would be by no means certain to touch the anthers or stigma.

Psoralea Onobrychis Nutt.[1]—The plants grow in large patches and bear many racemes of blue flowers, which are very attractive to bees. Greenish lines on the banner form path-finders. The wings and keel are depressed together, and return so as to cover the stamens. The stigma is raised considerably above the anthers and so strikes the bee in ad-

[1]On this species see Fœrste: BOT. GAZ., XIII, 152.

vance of them. The calyx tube is about two mm. deep, so that small bees which know how to force their way into the flower can reach the nectar. The flowers are sought by many insects, especially bees of the genus Megachile.

Visitors (7 days, June 26–July 11): Hymenoptera—*Apidæ*: (1) *Apis mellifica* L. ☿, s.; (2) *Ceratina dupla* Say ♀, s.; (3) Megachile sp. ♂ ♀, s. and c. p.; (4) *M. addenda* Cr. ♂, s.; (5) *M. mendica* Cr. ♀, s. and c. p., ab.; (6) *M. brevis* Say ♂ ♀, s. and c. p., ab.; (7) *M. perbrevis* Cr. ♂, s.; (8) *Anthidium emarginatum* Say ♂, s.; (9) *Alcidamea producta* Cr. ♀, s. and c. p.; (10) *Osmia distincta* Cr. ♀, s.; (11) *Cœlioxys 8-dentata* Say ♀, s.; (12) *Calliopsis andreniformis* Sm. ♂ ♀, s. and c. p., ab. *Andrenidæ:* (13) *Agapostemon radiatus* Say ♀, s. and c. p.; (14) *Halictus coriaceus* Sm. ♀, s.; (15) *H. Lerouxii* St. Farg. ♀, s.; (16) *H. flavipes* F. ♂ ♀, s,; (17) Colletes sp. ♂, s. *Eumenidæ*: (18) *Odynerus dorsalis* F., s.; (19) *O. arvensis* Sauss., s. *Sphecidæ:* (20) *Priononyx atrata* St. Farg.; (21) *P. thomæ* F., both s.

Diptera—*Bombylidæ:* (22) *Anthrax sinuosa* Wied.; (23) *A. parvicornis* Lw., both s.

Lepidoptera—*Rhopalocera:* (24) *Papilio philenor* L.; (25) *Pieris protodice* Bd.-Lec. *Noctuidæ:* (26) *Anthœcia jagnarina* Gn., all 3 s.

Amorpha canescens Nutt.—The proterogyny of this plant and of A. fruticosa has been recorded by Beal.[2] Müller[3] has figured A. fruticosa and described its mechanism, confirming Beal's view in regard to proterogyny and adding that self-fertilization may occur in absence of insects. Meehan[4] also has observed the flowers, but while he recognized the fact that the pistil matures a day before the anthers, he holds that the flowers are self-fertilized, and that too after having observed that "the flowers seem very grateful to the pollen-gathering insects." He also considers the late enlargement of the banner as wholly superfluous, disregarding the fact that the real instrument of attraction is the whole inflorescence, and that anything which increases the conspicuousness of the spike is an advantage to all of the flowers.

Visitors (June 24–26 and 28): Hymenoptera—*Apidæ:* (1) *Bombus americanorum* F. ♀ ☿, s. and c. p.; (2) *Ceratina dupla* Say ♀, s.; (3) *Megachile brevis* Say ♀, s. and c. p.;

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[2] Am. Nat. I, 405.

[3] Weitere Beobachtungen, II, 244, and Pl. II and III, figs. 52-54.

[4] Proc. Acad. Sci. Phil., 1887, 329, 330. See also Delpino: Ult. osservazioni, I, 67, 68.

(4) *Alcidamea producta* Cr. ♀, s.; (5) *Andronicus cylindricus* Cr. ♀, c. p.: (6) *Heriades carinatum* Cr. ♀, c. p.; (7) *Cœlioxys 8-dentata* Say ♀, s.; (8) *Calliopsis andreniformis* Sm. ♀, s. *Andrenidæ:* (9) Halictus sp. ♂, s.; (10) *H. pilosus* Sm. ♀, s.: (11) *H.* ~~*connexus* Cr~~. ♀, s. and c. p.; (12) *Prosopis affinis* Sm. ♀, f. p.; (13) *P. pygmæa* Cr. ♀, f. p. *Eumenidæ:* (14) *Eumenes fraternus* Say, s. *Sphecidæ:* (15) *Ammophila intercepta* St. Farg.; (16) *A. vulgaris* Cr.; (17) *Priononyx atrata* St. Farg,, all 3 s.

Diptera—*Syrphidæ:* (18) *Paragus bicolor* F.; (19) *Tropidia mamillata* Lw., both f. p.

Coleoptera—*Chrysomelidæ:* (20) *Diabrotica 12-punctata* Oliv.; (21) *D. atripennis* Say. *Meloidæ:* (22) *Macrobasis unicolor* Kby., all f. p.

(11) H. confusus Sm.

Petalostemon violaceus Mx.—The plants grow in rather large patches, the stems being terminated by several close spikes of rose-purple flowers, which I regard as proterandrous. The corolla is nearly regular, and it seems as if it might as well be quite so, as far as its effect upon insects is concerned. Indeed, the calyx has more to do with determining the character of the visitors. The number of wasps is far greater than would be expected on a flower of the complicated structure we find in most Papilionaceæ. The organs are so exposed that the stigma is pollinated and the pollen is collected by bees crawling around the spikes. The nectar is not very deeply seated, the calyx being 3 to 4 mm. deep; but the flowers are visited more frequently for pollen than for nectar.

Visitors (7 days, July 5–30): Hymenoptera—*Apidae:* (1) *Apis mellifica* L. ☿. s. and c. p.; (2) *Bombus virginicus* Oliv. ☿, s. and c. p.; (3) *B. separatus* Cr. ♂ ♀ ☿, s. and c. p.; (4) *B. americanorum* F, ♀ ☿, s. and c. p., ab.; (5) *B. scutellaris* Cr. ☿, s. and c. p.; (6) *Melissodes obliqua* Say ♂ ♀, s. and c. p.; (7) *M. bimaculata* St. Farg. ♂, s.; (8) *Ceratina dupla* Say ♀, s. and c. p.[5]; (9) *Megachile brevis* Say ♀, s. and c. p., ab.; (10) *M. inimica* Cr. ♀, s. and c. p.; (11) *Andronicus cylindricus* Cr. ♀, s. and c. p.; (12) *Cœlioxys 8-dentata* Say, s.; (13) *Epeolus remigatus* F. ♀, s.; (14) *E. lunatus* Say ♂ ♀, s., ab. *Andrenidæ:* (15) *Agapostemon nigricornis* F. ♀, s. and c. p., ab.; (16) *Augochlora pura* Say ♀, c. p.; (17) *A. lucidula* Sm. ♀, s.; (18) Halictus sp. ♀, c. p.; (19) *H.*

[5] This bee is said to be destitute of pollenigerous organs, but it certainly has a thin scopa and I have often seen it collecting pollen. In Am. Nat. XIII, 430, Prof. Trelease mentions having seen it collecting pollen of Lobelia syphilitica.

parallelus Say ♂ ♀, s. and c. p., ab.; (20) *H. flavipes* F. ♀, s. and c. p., ab.: (21) *H. pilosus* Sm. ♀, c. p.; (22) *H. con*fusus Sm. ~~*nexus* Cr.~~ ♀, c. p.; (23, 24) Colletes spp. ♀, s. and c. p. *Eumenidae:* (25) *Eumenes fraternus* Say, s. *Bembecidae:* (26) *Bembex nubillipennis* Cr. s. *Sphecidae:* (27) *Ammophila procera* Klug.: (28) *A. intercepta* St. Farg.; (29) *Sphex ichneumonea* L.; (30) *Priononyx atrata* St. Farg.—all s. *Scoliidae:* (31) *Elis plumipes* Dru., s.

Diptera—*Sarcophagidae:* (32) Sarcophaga sp.

Lepidoptera—*Rhopalocera:* (33) *Lycaena comyntas* Godt.; (34) *Colias caesonia* Stoll; (35) *C. philodice* Godt.; (36) *Pholisora catullus* F.—all s.

Coleoptera—*Meloidae:* (37) *Epicauta pennsylvanica* De G.; (38) *E. trichrus* Pall.—both s. and f. p.

Hemiptera—*Capsidae:* (39) *Calocoris rapidus* Say, s. *Pentatomidae:* (40) *Euschistus variolaris* P. B., s.

Tephrosia Virginiana Pers.—The banner is light yellow, the wings and keel are pink. The anthers dehisce in the keel, and when the keel is depressed the pollen is carried out on a brush of hairs which covers the upper edge of the style. The stigma itself is covered with pollen at first and aids in carrying it out so as to strike the bee, but it is probably not receptive until after the pollen has been removed and its surface has been rubbed, as in the case of Anthyllis, etc.[6] The flowers are visited for honey and pollen by *Megachile brevis* Say ♀.

Desmodium.—The behavior of this flower was described by Bessey in the case of D. sessilifolium,[7] and by Foerste in D. canescens.[8] The keel incloses the stamens and pistil, and is held in position by two processes on the base of the banner. The keel has such a strong tendency to fly down that it bends the inclosed organs downward with it; the stamens and pistil, therefore, have a strong tendency to fly up. The wings also are held by the banner, and are so closely united with the keel that when one of them is released the keel is released with it. The wings thus act as triggers by which the flower is discharged; but the discharge may also be effected by raising the banner, or by forcing the banner and keel apart.

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[6] See Müller, Fertilization of Flowers, 173.
[7] Am. Nat. XIX, 711–713, figs. 1–4.
[8] Bot. Gazette, XIII, 152.

The filaments are expanded at the tips and are turned outward a little, so as to form a little basket in which the pollen is received when discharged, and which aids in throwing the pollen when the trap is sprung.

Foerste says, "The fact that the tenth stamen is free is *a priori* evidence of the existence of honey." Bessey seems to have supposed that nectar was present and that the spots on the base of the banner were nectar-guides. But the stamen tube is closed below and nectar is wanting; the flower belongs with such flowers as Genista tinctoria and Sarothamnus scoparius,[9] which are adapted to be visited only by pollen-collecting bees, and which permit only one visit.

When a bee lights upon the flower it thrusts its head under the base of the banner while with its legs it forces one or both of the wings outward and downward so as to dislodge it from the banner. This frees the keel, which snaps down violently. The column, being in turn freed from the keel, flies up and hurls the pollen against the ventral surface of the bee.

Desmodium Canadense DC.—This is the largest flowered species, and can only be exploded easily by the largest bees. Consequently, humble bees are more abundant than on any of the other species.

Visitors (July 20, Aug. 15): *Apidae*: (1) *Bombus separatus* Cr. ☿; (2) *B. americanorum* F. ☿; (3) *Melissodes bimaculata* St. Farg. ♀; (4) *Megachile brevis* Say ♀, rare, and only opens the flower with difficulty.

Desmodium cuspidatum T. & G.—Visitors (Aug. 13 and 22): *Apidae:* (1) *Bombus americanorum* F. ☿; (2) *Melissodes bimaculata* St. Farg. ♀; (3) *Megachile brevis* Say ♀.

Desmodium Dillenii Darl.—Visited by *Bombus americanorum* F. ☿.

Desmodium paniculatum DC.—Visitors (4 days, Aug. 8–Sept. 10): *Apidae:* (1) *Bombus americanorum* F. ☿; (2) *Melissodes bimaculata* St. Farg. ♀; (3) *Megachile brevis* Say ♀; (4) *M. mendica* Cr. ♀; (5) *Calliopsis andreniformis* Sm. ♀.

Desmodium sessilifolium T. & G.—Visited by *Megachile brevis* Say ♀.

Desmodium Marilandicum Boott.—The small flowers of this plant are exploded by a little bee, *Calliopsis andreniformis* Sm. ♀.

We have observed that the flowers are adapted to the

[9] See Müller, Fertiliztion of Flowers.

pollen-collecting bees; so that, at the start, all male bees and all cuckoo-bees are excluded. Then the visitors must be intelligent enough to know how to snap the flowers and to keep from being frightened by their explosion. For this reason the visitors of Desmodium are the most intelligent of the genera to which they belong, or are at least more used to visiting flowers of complicated structure.

On the six species of Desmodium mentioned above there occur two species of Bombus, one of Melissodes, two of Megachile and one of Calliopsis. Of eight species of Bombus which occur in my neighborhood, B. americanorum is the most intelligent and the most important visitor of irregular flowers. This bee was seen on the flowers of four species, while B. separatus was seen only on D. Canadense. Of seven species of Melissodes, M. bimaculata is most common on irregular flowers, while the others occur more often on Compositæ. Most of twelve species of Megachile also limit their attentions to Compositæ, while M. brevis and M. mendica are common on irregular flowers. The same is true of the five species of Calliopsis, C. andreniformis being the only one observed on irregular flowers.

The larger flowered species also limit their visitors by the strength required to discharge them. Thus, D. Canadense is most abundantly visited by humble bees, since the smaller bees, like Megachile, can only snap them with difficulty. The little Calliopsis andreniformis is neither strong enough to spring the trap nor is it large enough to receive the pollen. But while the small bees are excluded from the large flowers, the large bees can easily discharge and receive the pollen of the smaller flowers. As a consequence, the smaller flowers, like D. paniculatum, are sought by a greater number of species. But the very small flowers of D. Marilandicum seem to depend exclusively upon Calliopsis.

Carlinville, Ill.

[From the BOTANICAL GAZETTE, Vol. XV, No. 8.]

Flowers and insects. V.

CHARLES ROBERTSON.

Astragalus Mexicanus A. DC.—The flowers are cream-color, often with a bluish tinge at the tip of the keel. The wings and keel are closely fastened together, so that they must be depressed simultaneously. The rigid banner is folded over the wings and keel, and projects straight forward in front of the calyx tube. This tube measures about 8 mm., and the parts of the flower are so contracted beyond it that after a bee has forced its head in so as to touch the anthers, it still needs a proboscis 10 to 13 mm. long to obtain the sweets. The petals are thus disposed so as to limit the accessibility of the nectar and to restrict the place of pollen-contact to the underside of the bee's head. The stigma only slightly surpasses the anthers and may touch the bee a little in advance of them, but self-pollination may occur in absence oi insects.

The flower is adapted to the longest-tongued bees. From its early blooming it is especially exposed to Bombus females and to species of Synhalonia. On three days, April 27, 30, and May 2, I observed the following visitors:

Hymenoptera—*Apidæ:* (1) Bombus separatus Cr. ♀, s., once; (2) B. americanorum F. ♀, s. ab.; (3) B. pennsylvanicus DeG. ♀, s.; (4) Synhalonia speciosa Cr. ♂ ♀, s., ab.; (5) S. atriventris Sm. ♀, s. and c. p., very ab.

Four butterflies were seen sucking, viz.: Papilio asterias, Colias philodice, Nisoniades icelus and N. juvenalis, but they are mere intruders, since they steal the honey without forcing down the keel.

Strophostyles angulosa Ell.[1]—The keel is bent strongly to the right and curves around so that its tip stands over its base. The base is large and sack-like and is produced above into a ridge which opposes the passage to the nectary. The left wing is turned to the right, so that the bee is required to alight upon the right side, and she enters the flower between the tip and the basal process of the keel. Seizing this process with her front feet, the bee pulls the keel downward and backward, whereupon the stigma and the pollen-laden brush of the style sweep out over her thorax. In this way the stigma receives pollen already deposited by an-

[1] This flower is described by Foerste in Am. Nat. XIX, 887, 888, figs. 1-5. I did not see a bee depress the keel in the way described by him.

other flower, and the style-brush leaves a new load. As soon as the bee lets go her hold upon the basal process, the keel returns to its place against the banner, and the style draws back into it.

Visitors: Hymenoptera—*Apidæ:* (1) Megachile brevis Say ♀, s. and c. p.; (2) M. exilis Cr. ♂, s.

Extranuptial nectaries.[2]—The following insects were taken while obtaining nectar from these structures:

Hymenoptera—*Andrenidæ:* (1) Augochlora pura Say; (2) Halictus flavipes F.; (3) H. confusus Sm. *Vespidæ:* (4) Vespa germanica F.; (5) Polistes pallipes St. Farg. *Eumenidæ:* (6) Odynerus pedestris Sauss. *Crabronidæ:* (7) Oxybelus 4-notatus Say. *Philanthidæ:* (8) Philanthus punctatus Say; (9) Cerceris clypeata Dahlb.; (10) C. kennicottii Cr.: (11) C. finitima Cr. *Larridæ:* (12) Larra acuta Patton. *Sphecidæ:* (13) Pelopoeus cementarius Dru.; (14) Chalybion cæruleum L. *Pompilidæ:* (15) Agenia longula Cr. *Mutillidæ:* (16) Sphærophthalma macra Cr. *Formicidæ:* (17) A black species not abundant enough to interfere with other insects or to suggest a thought of myrmecophilism. *Chrysididæ:* (18) Hedychridium dimidiatum Say. *Braconidæ:* (19) Apanteles sp.; (20) Microdus sp.

Diptera—*Syrphidæ:* (21) Mesograpta marginata Say. *Empidæ:* (22) Empis sp. *Tachinidæ:* (23) Eggeria? sp. *Sarcophagidæ:* (24–25) Sarcophaga spp. *Muscidæ:* (26) Lucilia cornicina F. *Anthomyidæ:* (27) Anthomyia sp. *Ortalidæ:* (28) Camptoneura picta F.; (29) Rivellia quadrifasciata Macq. *Geomyzidæ:* (30) sp. *Drosophilidæ:* (31–32) spp.

Hemiptera—*Capsidæ:* (33) Lygus pratensis L.

Amphicarpæa Pitcheri[3] Torr. & Gray.—The pale blue flowers are approximated in a rather close raceme, so that the attractive function is performed by the inflorescence and does not depend especially upon the banner, as in solitary flowers. For the same reason the wings and keel are relieved of their special office of affording a landing-place for the bees to settle upon. Accordingly, these insects alight upon the flower-cluster and crawl from one flower to another. The calyx-tube is very long (6 mm.), which makes the nectar inaccessible to short-tongued visitors. The petals, also, being freed from their original functions by the flower-cluster, are disposed so as to make the nectar still more

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[2] For a resume of the subject of extranuptial nectaries and for reference to the literature see Trelease: Myrmecophilism, Psyche Feb.-March, 1889, 171-180.

[3] On the fertilization of A. monoica, see Meehan: Proc. Acad. Nat. Sci. Phila., 1887, 323-325.

inconvenient for short tongues and to limit the place of pollen-contact to the underside of the visitor's head. The broad banner is folded over the other parts and is held tightly by the calyx-tube, so that with the closely approximated wings and keel it makes it difficult for a visitor with a proboscis shorter than 11 mm. to reach the nectar.

The flower is visited for nectar by *Bombus americanorum* F. ♂ ♀, and by the ruby-throated humming bird, *Trochilus colubris* L.

Cercis Canadensis L.—The red-purple flowers cover the trees before their own leaves and those of other trees appear. The trees can then be seen for miles and must attract bees from afar. The stamens are distinct and not firmly enclosed by the petals, and the calyx is broad and shallow. Accordingly, both honey and pollen are accessible to small and little specialized bees, like Halictus.

Although one of the least specialized of Leguminosæ, Cercis shows one of the most peculiar sets of visitors—the effect of early blooming. Of the bees with abdominal pollen-brushes, which are very fond of flowers of Papilionaceæ, Osmia, which flies in early spring, is abundant, while Megachile, which flies in summer, is absent. Later blooming species are visited by Megachile, while Osmia is absent. Cercis also resembles early flowers by being visited only by females of Bombus, while many flowers blooming in summer are visited by the males and workers. Synhalonia, and Anthophora also as far as I have observed, is only found on early flowers. If Cercis bloomed in summer, I should expect also to find Sphecidæ among its guests, as in the cases of Amorpha and Petalostemon. The flower is further remarkable for being abundantly visited by Colletes, C. inæqualis being more common on it than on any other flower known to me.

On six days, between April 21 and May 5, I captured the following visitors:

Hymenoptera—*Apidæ:* (1) Apis mellifica L. ☿, s. and c. p., ab.; (2) Bombus virginicus Oliv. ♀, s.; (3) B. separatus Cr. ♀, s. and c. p.; (4) B. vagans Sm. ♀, s.: (5) B. americanorum F. ♀, s., ab.: (6) B. pennsylvanicus DeG. ♀, s., ab.; (7) Anthophora ursina Cr. ♂ ♀, s., freq.; (8) Synhalonia speciosa Cr. ♂ ♀, s. and c. p., ab.; (9) S. honesta Cr. ♂, s.; (10) Ceratina dupla Say ♂, s.; (11) Osmia lignaria Say ♂ ♀, s. and c. p.; (12) O. atriventris Cr. ♀, s. and c. p.; (13) O. albi-

ventris Cr. ♀, s. and c. p.; (14) O. latitarsis Cr. ♂, s.; (15) Nomada luteola St. Farg. ♂ ♀, s.; (16) N. bisignata Say ♂ ♀, s. *Andrenidæ:* (17–18) Andrena spp. ♀, s. and c. p.; (19) A. hirticeps Sm. ♀, s.; (20) A. valida Say ♀, s. and c. p.; (21) Augochlora labrosa Say ♀, s.; (22) Halictus coriaceus Sm. ♀, s.; (23) H. lerouxii St. Farg. ♀, s. and c. p.; (24) H. flavipes F. ♀, s. and c. p., ab.; (25) H. zephyrus Sm. ♀, s.; (26) H. pilosus Sm. ♀, s. and c. p.; (27) H. confusus Sm. ♀, s. and c. p.; (28) H. stultus Cr. ♀, s. and c. p., ab.; (29) Colletes inæqualis Say ♂ ♀, s. and c. p., ab.; (30) C. canadensis Cr. ? ♀, s. and c. p. *Vespidæ:* (31) Polistes pallipes St. Farg. s.

Diptera—*Bombylidæ:* (32) Bombylius fratellus Wied., s. *Empidæ:* (33) Empis sp., s.

Lepidoptera—*Rhopalocera:* (34) Lycæna comyntas Godt.; (35) Nisoniades icelus Lintn., both s.

Coleoptera—*Cerambycidæ:* (36) Molorchus bimaculatus Say.

Cassia Chamaecrista L.[4]—The sickle-shaped pistil is turned either to the right or to the left, holding the stigma in such a position that it touches the bee upon the side; the flower is therefore an example of what Delpino calls a *pleurotribe* flower. Ten long black anthers with terminal pores turn in an opposite direction from the pistil. The petals are bright yellow, the upper ones are provided with a little red at base which serves as a path-finder, but not as a nectar-guide, since nectar is wanting. All are widely expanded and flexible except the lateral one toward which the anthers turn, which is erect and strongly incurved and so stiff that it commonly breaks on being bent back.

The flowers are visited exclusively by bumble-bee females and workers in search of pollen. Landing upon the anthers they seize them between their mandibles and stroke them downwards with a sort of milking motion. The pollen being thus forced out of the terminal anther-pores falls either directly upon the bee or upon the lateral petal which is pressed close against the bee's side. In this way the side of the bee which is next to the incurved petal receives the most pollen. Both right and left-hand flowers are found upon the same plant. A bee visiting a left-hand flower receives pollen upon the right side and then flying to a right-hand flower, strikes the same side against the stigma.

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[4] See J. E. Todd. On the flowers of Solanum rostratum and Cassia Chamæcrista, Am. Nat. XVI, 281-287. fig. 2.

Visitors: *Apidae*: (1) Bombus virginicus Oliv. ☿; (2) B. separatus Cr. ☿; (3) B. americanorum F. ♀ ☿; (4) B. scutellaris Cr. ☿—all c. p. Megachile brevis Say ♀ mutilates the petals by cutting out large circular pieces to use in her nest.

Extranuptial nectaries.—The extrafloral nectaries of this plant and of C. Marilandica are situated on the upper side and near the base of the petioles, being cupuliform in Chamæcrista and club-shaped in Marilandica.

Visitors: (Aug. 2, 7, 8) Hymenoptera—*Andrenidæ*: (1) Halictus confusus Sm. *Eumenidæ*: (2) Odynerus foraminatus Sauss. *Larridæ*; (3) Larra argentata Beauv. *Sphecidæ*: (4) Pelopoeus cementarius Dru.; (5) Chalybion cæruleum L. *Pompilidæ*: (6) Pompilus sp.; (7) P. navus Cr.; (8) Priocnemis fulvicornis Cr. *Scoliidæ*: (9) Tiphia inornata Say. *Mutillidæ*: (10) Mutilla hexagona Say; (11) M. sayi Blake; (12) Sphærophthalma macra Cr. *Formicidæ*: (13, 14) A black and a large red species. *Chrysididæ*: (15) Holopyga ventralis Say; (16) Chrysis montana Aaron. *Braconidæ*: (17) Apanteles sp.

Diptera—*Tabanidæ*: (18) Tabanus lineola F. *Syrphidæ*: (19) Mesograpta marginata Say; (20) M. polita Say. *Tachinidæ*: (21) sp.; (22) Phorocera sp. *Sarcophagidæ*: (23) Sarcophaga sp. *Muscidæ*: (24) Lucilia cornicina F. *Anthomyidæ*: (25) Anthomyia sp. *Ortalidæ*: (26) Rivellia quadrifasciata Macq.

Hemiptera—*Capsidæ*: (27) Lygus pratensis L.

Lepidoptera—*Rhopalocera*: (28) Callidryas eubule L. (Trelease notes.)

Cassia Marilandica[5] L.—Three petals form an upper lip, while two form a lower, all of them being entirely yellow. Fritz Müller[6] mentions several flowers in which there are two kinds of stamens with different functions. In this flower there are three sets of stamens, all with different functions. The three upper are reduced to dark scale-like rudiments, which serve as pathfinders. Accordingly, the red spots which occur on the upper petals of Chamæcrista are wanting in Marilandica. Four short stamens furnish pollen for the visitors. Bumble-bees milk the pollen out of these, using their jaws as in the case of Chamæcrista. Two long stamens, one on each side of the style, furnish pollen for cross-fertilization.

[5]See Meehan: Proc. Acad. Sci. Phil., 1886, 314-318. Also Torr. Bull. XIII, 249. Figures of the stamens and style of C. occidentalis and of the flower of C. acutifolia by Todd, in Am. Nat. XVI, 285, represent C. Marilandica fairly well.

[6]Nature XVII, 364.

They have inflated anthers, which probably have a bellows-like action like the long stamen of Solanum rostratum[7] and the anthers of Rhexia Virginica.[8] Between the style and a long stamen is another long stamen with an anther like those of the short stamens. Bees, no doubt, force the pollen out of this as they do from the short stamens. The style is turned sometimes to the right, sometimes to the left, and the flower itself is turned slightly to one side or the other, so that the stigma touches the side of the visitor, making the flower *pleurotribe*. According to Meehan, the flowers fail to produce seed under a net. Both he and Leggett[8] saw bumble-bees collecting the pollen. I have seen the flower visited for pollen by Bombus americanorum F. ☿.

Extranuptial nectaries.—Visitors :(on one occasion) A large red ant; Sarcophaga sp.; Anthomyia sp.; Camptoneura picta F. (Ortalidæ); Coccinella sanguinea L.

Carlinville, Ill.

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[7]Todd: l. c. [8]Torr. Bull. VIII, 102-104.

39.

[From the BOTANICAL GAZETTE, March, 1891.]

Flowers and insects. VI.

CHARLES ROBERTSON.

Triosteum perfoliatum L.—In the bud the style is bent and the stigma is pressed against the opposing lobes of the corolla. As soon as the lobes separate the style straightens and the stigma is thrust out. The stigma rises from 3 to 4 mm. above the anthers and appears to be receptive while they are still indehiscent, so I regard the flower as proterogynous. The corolla continues to lengthen until the second stage. In this stage the anthers are dehiscent, and the stigma is turned to one side. The flowers are rather dark purple and collected in inconspicuous clusters in the axils of the perfoliate leaves. Nectar is secreted in a gibbosity in the base of the corolla. The corolla is from 14 to 16 mm. long and is adapted to long-tongued bees.

Visitors: (May 18 and 23) *Apidae:* (1) Bombus Ridingsii Cr. ♀, s.; (2) B. vagans Sm. ♀, s., visited all of the open flowers and forced its proboscis into several buds, whose lobes had hardly begun to loosen, but which contained an abundance of nectar; (3) B. americanorum F. ♀, s.; (4) Anthophora abrupta Say ♂, s,; *Andrenidae:* (6) Augochlora pura Say ♀, s. and c. p., crawls into the tube; (7) Halictus Lerouxii St. Farg. ♀, c. p.

Cephalanthus occidentalis L.—The first peculiarity of the flower that strikes one is the great difference in the height of the anthers and stigma. Indeed, it looks like a long-styled dimorphous flower. The anthers are at the mouth of the tubular corolla, while the stigma rises 7 mm. higher. It looks as if the pollen could never touch the same part of the insect which comes in contact with the stigma. The disparity is accounted for by the fact that the style itself serves to expose pollen to the visitors. In the bud the anthers dehisce, depositing all of

their pollen in a conical mass upon the summit of the style. The style rises to its usual height and holds the pollen where it will easily touch insects lighting upon the globular head of flowers. After the pollen has been removed, the stigma becomes receptive, and the flower is now in the second or female stage.

Meehan[1] has taken the loading of the pollen upon the tip of the style as a plain case of self-fertilization. But it is no more a case of self-fertilization than the loading of pollen upon the style brush of Campanula. As far as they go, Meehan's observations do not support the view that self-fertilization occurs even in absence of insects, for he says: "Numerous seeds are in every head examined. Carefully dissecting one, I found it had 279 flowers, of these 225 perfected seeds, and only 54 failed." He had made the gratuitous assumption that fullness of fruit is evidence of self fertilization.[2] As between cross and self fertilization, the 225 fruitful cases prove nothing; the failure of one in five flowers is presumptive evidence against the power to self-fertilize.

The round heads of white flowers are very attractive to insects. The corolla tubes are 9 mm. long and are very narrow, especially below. The flowers are thus adapted to long and thin tongues. The nectar rises in the tube so that shorter tongued insects can reach some of it, but the predominant visitors are butterflies. On 11 days, between July 5th and August 17th, I observed the following visitors:—

Hymenoptera—*Apidae:* (1) Apis mellifica L. ☿, s., ab.; (2) Bombus virginicus Oliv. ☿, s. and c. p., freq.; (3) B. separatus Cr. ♂♀☿, s., ab.; (4) B. Ridingsii Cr. ♂, s., one; (5) B. americanorum F. ♂♀☿, s. and c. p., ab.; (6) B. pennsylvanicus De Geer, ♀☿, s., freq.; (7) B. scutellaris Cr. ☿, s., one; (8) Emphor bombiformis Cr. ♀, s., one; (9) Xenoglossa pruinosa Say ♂, s.; (10) Melissodes obliqua Say ♀, s.; (11) M. bimaculata St. Farg. ♂, s.; (12) Ceratina dupla Say ♀, s.; (13) Megachile mendica Cr. ♀, c. p.; (14) Nomada texana Cr. ♀, s.; *Andrenidae:* (15) Halictus Lerouxii St. Farg. ♀, s., one; (16) H. ligatus Say ♀, s., one; (17) Agapostemon nigricornis F. ♀, s.; bicolor (18) A. radiatus Say ♂, s.; (19) A. texanus Cr. ♀, s.; (20) Prosopis affinis Sm. ♀, f. p.; *Pompilidae:* (21) Priocnemis ful-

[1]Contributions to the Life Histories of Plants. Proc. Acad. Nat. Sci. Phila., 1887, 323–333; 4 figs. See also Bull. Torr. Bot. Club, xv, 54.

[2] Bot. Gazette xiii, 157.

vicornis Cr., s., one; *Scoliidae:* (22) Myzine sexcincta F. s., one.

Lepidoptera—*Rhopalocera:* (23) Papilio philenor L.; (24) P. asterias F., ab.; (25) P. troilus L.; (26) Pieris protodice Bd.-Lec.; (27) P. rapae L.; (28) Colias caesonia Stoll; (29) C. philodice Godt.; (30) Danais archippus F. ab.; (31) Argynnis cybele F.; (32) Phyciodes tharos Dru.; (33) Pyrameis atalanta L., ab.; (34) P. huntera F.; (35) P. cardui L.; (36) Limenitis disippus Godt.; (37) Satyrus alope F.; (38) Thecla humuli Harr.; (39) Chrysophanus thoe Bd.-Lec., ab.; (40) Lycaena pseudargiolus Bd.-Lec.; (41) L. comyntas Godt.; (42) Pamphila zabulon Bd.-Lec.; (43) P. huron Edw.; (44) P. peckius Kby.; (45) P. cernes Bd.-Lec.; (46) P. delaware Edw.; (47) Nisoniades juvenalis F.; (48) Eudamus tityrus F. ab.; *Arctiidae:* (49) Utetheisa bella L.; *Pyralidae:* (50) Scepsis fulvicollis Hübn.—all s.

Diptera—*Conopidae:* (51) Physocephala tibialis Say, s.; *Syrphidae:* (52) Sphaerophoria cylindrica Say, s.; (53) Volucella evecta Walk., s.; (54) Eristalis tenax L., s., ab.; (55) E. latifrons Lw., s. and f. p.; (56) Syritta pipiens L., s.; *Muscidae:* (57) Musca domestica L., f. p.

Coleoptera—*Coccinellidae:* (58) Hippodamea 15-maculata Muls., f, p.; *Scarabaeidae:* (59) Trichius piger F., f. p.

Hemiptera—*Lygaidae:* (60) Oncopeltus fasciatus Dall., s. /e

Lobelia[1] *spicata* Lam.—In my neighborhood this is the earliest blooming Lobelia. The plants are scattered and are neither so attractive to insects nor so easily observed as the next species. The flowers are white and are arranged in rather loose spikes. They are proterandrous, like the other species which have been observed. The corolla tube is 4–6 mm. long, and the nectar is therefore only readily accessible to tongues of medium length.

Visitors: (5 days, May 31 to June 12) Hymenoptera—*Apidae:* (1) Ceratina dupla Say ♀; (2) Megachile brevis Say ♀; (3) Alcidamea producta Cr. ♀.

Lepidoptera—*Rhopalocera:* (4) Pieris protodice Bd.-Lec.; (5) P. rapae L.; (6) Chrysophanus thoe Bd.-Lec.; (7) Ancyloxypha numitor F.; (8) Pamphila peckius Kby.; (9) P. cernes Bd.-Lec.—all s.

Lobelia leptostachys A. DC.—Resembles L. spicata, but the spikes are more conspicuous, and the corolla tubes are a

[1] On the fertilization of Lobelia see Mueller: Fertilization of Flowers, 365, 633.

little longer. On account of later blooming, the list shows
bees l~~e~~ss of the genus Melissodes and an increase in Megachile.

Visitors: (7 days, July 8 to 31) Hymenoptera—*Apidae:* (1) Apis mellifica L. ☿, s.; (2) Bombus separatus Cr. ☿, s.; (3) B. americanorum F. ☿, s.; (4) Melissodes obliqua Say ♂, s.; (5) M. bimaculata St. Farg. ♂, s; (6) Ceratina dupla Say ♀, s.; (7) Megachile rufimanus Rob. (MS) ♂, s.; (8) M. brevis Say ♂♀, s. and c. p.; (9) M. petulans Cr. ♂, s.; (10) M. exilis Cr. ♂, s.; (11) Anthidium emarginatum Say ♂♀, s.; (12) Andronicus cylindricus Cr. ♀, s.; (13) Coelioxys 8-dentata Say ♂, s.; *Andrenidae:* (14) Agapostemon nigri~~c~~ornis F. ♀, s.; bicolor (15) Augochlora pura Say ♂♀, s., the male sucking through the slit in corolla; (16) Halictus fasciatus Nyl. ♂, s.; (17) H. pilosus Sm. ♀, c. p.

Lepidoptera—*Rhopalocera:* (18) Lycaena comyntas Godt.; (19) Pamphila cernes Bd.-Lec.; (20) Nisoniades juvenalis F.—all s.

Diptera—*Bombylidae:* (21) Systoechus vulgaris Lw., s.

Lobelia syphilitica L.—The large blue flowers are specially adapted to bumble-bees. Delpino saw it visited by Bombus italicus and B. terrestris. In this country Trelease[1] saw it visited by several species of Bombus. As intruders he observed Osmia sp. and Ceratina dupla Say ♀ collecting pollen.

Visitors: (4 days, Aug. 12 to Sept. 3) *Apidae:* (1) Bombus separatus Cr. ♀, s.; (2) B. virginicus Oliv. ☿. s. and c. p.; (3) B. vagans Sm. ☿, s. and c. p.; (4) B. americanorum F. ♀☿, s., ab.; *Andrenidae:* (5) Augochlora pura Say ♀; (6) Halictus confusus Sm. conn~~e~~xus Cr. ♀—both collecting pollen which they work out of the anther-tube with their jaws and front feet.

Lepidoptera—*Rhopalocera:* (7) Danais archippus F.; (8) Papilio philenor L.—both s.

Lobelia cardinalis L.—Trelease (*l. c.*) saw this flower visited by humming-birds, Trochilus colubris L. I have never failed to find them about the flowers, and there is no doubt that the flowers are specially adapted to them. The pendant lip shows that the flower is intended to be visited by a bird or insect which is in the habit of sucking the sweets from flowers without resting upon them. I have also seen the flowers visited by Papilio philenor L. and P. troilus L.

On two occasions I counted five individuals of Bombus americanorum F. ☿, about the flowers. Sometimes one of

[1]On the fertilization of several species of Lobelia, Am. Nat. xiii, 427–432.

45

them would try to reach the nectar in front, but failing, would crawl down to the base of the flower and insert its tongue through the slit, but most of them only tried to reach the nectar through the slit. This is the only time I have seen a bumble-bee obtaining nectar illegitimately.

Augochlora pura and Halictus connexus also visit this plant confusus
for pollen, behaving as on the flowers of L. syphilitica.

Since the flowers of Lobelia are intended to be visited by insects entering below the stamen tube it is an imperfection that the tube has openings between the bases of the upper filaments, for this allows improper visitors to steal the nectar through the slits in the upper side of the corolla. Trelease saw Augochlora pura treating flowers of L. erinus in this way and I have observed the same thing in L. leptostachys and L. cardinalis.

Lobelia cardinalis × syphilitica.—Very many plants of the two preceding species grew together in a large patch. The ruby-throated humming-bird passed by L. syphilitica and only visited L. cardinalis. The bumble-bees visited L. syphilitica regularly, only stealing the nectar of L. cardinalis in the cases indicated; and they might not have done so, if they had not been drawn among them by L. syphilitica.

The insects which occurred on both species and which might
effect hybridization are Bombus americanorum, Augochlora pura, Halictus connexus and Papilio philenor. confusus

Among the plants I found nine specimens of the hybrid. The corolla is shorter and broader and the lobes shorter and firmer than in L. cardinalis, and is described by Schneck[1] as of a deep reddish or crimson-purple. There is abundant nectar, but the others seem imperfect. anthers

Twice I saw Bombus americanorum visit the flowers in the regular way, showing that it could reach the nectar easily. This led me to wonder if the humming-bird would visit the hybrid. Seeing one alight upon a limb over my head, I drew back and was rewarded by seeing him come down and visit the hybrid along with L. cardinalis. It was interesting to observe that, while Bombus americanorum could not suck the nectar of L. cardinalis properly and humming-birds did not visit L. syphilitica at all, the nectar of the hybrid was easily accessible to the one and its colors were attractive to the other.

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[1]Bot. Gaz. iii, 35.

Campanula Americana L.[1]—In the GAZETTE, xiii, 225, I have observed that this flower is in the first stage of irregularity, and that bees land upon the style and insert their tongues between the bases of the upper stamens. But, although the stigma is turned so as to strike the ventral surface of the bee, the stamens still retain the useless habit of covering the style on all sides with pollen. At first the style is straight so that the bee touches only the upper side, but afterwards it bends so that the bee may touch the sides and even the underside near the tip. But still much pollen is wasted by being fixed on the lower side. Megachile exilis, which visits the flower for pollen, regularly turns and hangs under the style so as to clean the pollen off the lower side. This is another illustration of the fact that in dichogamous flowers, which as a rule are only properly visited for nectar, the pollen often acts disadvantageously by attracting insects which remove it and neglect the flowers in the female stage.

The larger bees, which are the only insects adapted to the flower, visit it only for nectar and only touch the upper side of the style. I repeat the list given in the GAZETTE, l. c., with some additions.

Visitors: (11 days, July 10 to Aug. 28) Hymenoptera—*Apidae:* (1) Apis mellifica L. ☿; (2) Bombus virginicus Oliv. ♂☿; (3) B. separatus Cr. ♂; (4) B. americanorum F. ♂☿; (5) Melissodes bimaculata St. Farg. ♂♀; (6) Megachile brevis Say ♂☿—all sucking; (7) M. exilis Cr. ♂♀, s. and c. p.; *Andrenidae:* (8) Agapostemon radiatus Say ♂♀, s; (9) Augochlora pura Say ♀, c. p.; (10) Halictus Lerouxii St. Farg. ♂, s.; (11) H. coriaceus Sm. ♂♀, s; (12) Prosopis affinis Sm. ♀, f. p.; *Specidae:* (13) Ammophila sp. searching for nectar; *Scoliidae:* (14) Myzine sexcincta F. s.

Lepidoptera—*Rhopalocera:* (15) Pyrameis cardui L. s.; (16) Pholisara hayhurstii Edw., s.

Apocynum[2] *cannabinum* L.—The flowers are white, much smaller than in A. androsæmifolium, and the nectar is lodged in rather shallow receptacles, so that flies and other short-lipped insects can reach it. A. androsæmifolium, according to Ludwig, is visited by butterflies and cements its pollen to their tongues. I have found the pollen-masses of this species on the maxillary and labial palpi of bees, and but

[1] See Barnes: Bot. Gaz. x, 349, pl. x and vol. xi, 99.
[2] On literature of genus see Mueller: Fertilization of Flowers, 396, 631.

rarely on other parts of their tongue. The insects in the list are marked m. l. or t. according as the pollen masses were found on the maxillary or labial palpi, or on the ligula proper.

Visitors: (June 21, 25) Hymenoptera—*Apidæ:* (1) Apis mellifica L. ☿, l.; (2) Coelioxys 8-dentata Say ♂♀; (3) Stelis lateralis Cr. ♀; (4) Nomada articulata Sm. ♂, m. l.; (5) N. incerta Cr. ♀, m. l.; *Andrenidæ:* (6) Macropis steironem~~a~~ atis Rob. (MS) ♂♀; (7) Agapostemon radiatus Say ♀, m.; (8) Augochlora lucidula Sm. ♀; (9) Halictus fasciatus Nyl. ♀; (10) fuscus Sm. H. conn~~e~~xus Cr. ♂♀; (11) Colletes ~~sp.~~ ♂, m.; (12) Prosopis producta affinis Sm. ♀; *Eumenidæ:* (13) Odynerus foraminatus Sauss. t.; *Bembecidæ:* (14) Monedula ventralis Say; *Larridæ:* (15) Astata bicolor Say; *Sphecidæ:* (16) Ammophila vulgaris Cr.; (17) Isodontia philadelphica St. Farg., t.; (18) Priononyx thomæ F.; (19) P. atrata St. Farg.

Diptera—*Mycetophilidæ:* (20) Sciara sp.; *Bombylidæ:* (21) Anthrax alternata Say; *Syrphidæ:* (22) Allograpta obliqua Say; (23) Sphærophoria cylindrica Say; (24) Tropidia mamillata Lw.; (25) T. quadrata Say; *Empidæ:* (26) Empis sp.; *Tachinidæ:* (27) Cistogaster divisa Lw.; (28) Ocyptera enor Wlk. ~~sp.~~; (29) Jurinia apicifera Walk.; (30) Micropalpus sp.; (31) Acroglossa hesperidarum Will.; *Sarcophagidæ:* (32) Sarcophaga sp.; *Muscidæ:* (33) Lucilia caesar L.; (34) L. macellaria F.; *Anthomyidæ:* (35) Anthomyia sp.; (36) Limnophora sp.

Lepidoptera—*Rhopalocera:* (37) Argynnis cybele F.; (38) Thecla calanus Hübn.

Coleoptera—*Scarabacidae:* (39) Trichius piger F.

Hemiptera—*Capsidae:* (40) Lygus pratensis L.; *Lygacidae:* (41) Lygæus turcicus F., s.

Carlinville, Ill.

[From BOTANICAL GAZETTE, Vol. XVII.]

Flowers and insects. VII.

CHARLES ROBERTSON.

MARTYNIA PROBOSCIDEA Glox.—I know of but one station for this plant—on the banks of the Macoupin Creek, where it appears to be indigenous.

The pale bluish corolla measures about $5\frac{1}{2}$ cm. in length, its tube about $3\frac{1}{2}$ cm. The tube within is finely spotted with bluish; on the lower wall there are about three orange lines leading from the narrow part of the tube and expanding in a large spot on the lower lip. The throat above is spotted with reddish, on the sides with bluish. The middle lobe of the lower lip is streaked with bluish and is straight, while the others are reflexed.

The anthers lie against the upper wall in the median line, with their cells directed longitudinally. The stigma is in advance of them and closes when touched, as observed by Delpino.[1] The narrow part of the tube is about 8 mm. long which with other characters of the flower seems to indicate an adaptation to long-tongued bees. I have found the flowers in bloom from Aug. 19 to Sept. 14. Sept. 3, 1890, I saw *Bombus americanorum* F. ☿ sucking the honey, its thorax being streaked with pollen.

At Metropolis, Ill., Aug. 14, Mr. C. A. Hart found it visited by *Xenoglossa brevicornis* Rob. (MS.) ♂ ♀.

DIANTHERA AMERICANA L.—The plant is rather common in shallow water of streams, the stems rising from 3 to 9 dm. and bearing small clusters of purplish flowers.

The flowers are proterandrous. The two-lobed upper lip stands erect and is strongly marked with purple. The lower lip is formed by three widely divergent lobes, which are white, the middle one with much purple.

[1] Sugli apparecchi delle fecondazione nelle piante antocarpee, 1867.

A straight stamen stands on each side. The anther cells are widely separated; one stands vertically, facing the corresponding cell of the other stamen; the other, the outer one, is placed horizontally and has its dehiscent surface turned upwards. The stamens stand so erect that at first I wondered how the bee would come in contact with them. I also wondered why the anther cells are at right angles to each other. As a rule, only two flowers are in bloom in the umbel-like cluster at a time. The three lobes of the lower lip, which we have observed are strongly divergent, are curved upward, so that it is most convenient for the bee to enter between the middle and one of the lateral lobes. In this way it is apt to brush the vertical face of the inner anther-cell. To reach the other flower, the bee crawls directly upwards and approaches it from above. In crawling up out of one flower and down into the other the bee is likely to touch the horizontal faces of the outer anther-cells.

The corolla tube is about 5 mm. long, so that the nectar can be obtained by tongues of medium length. The flower is evidently adapted to bees, but is often visited by flies and butterflies. I have found it in bloom from June 23 to Aug. 24. On July 5 and 9 I observed the following visitors:—

Hymenoptera—*Apidae:* (1) Apis mellifica L. ☿, s., ab.; (2) Bombus virginicus Oliv. ☿, s.; (3) Melissodes palustris Rob. ♂, s., ab.; (4) M. bimaculata Lep. ♂♀, s., ab.; (5) Ceratina dupla Say ♀, s.; (6) Epeolus lunatus Say ♂♀, s.; *Andrenidae:* (7) Agapostemon nigricornis F. ♀, s.; (8) A. radiatus Say ♂♀, s.; (9) Augochlora pura Say ♀, s. and c. p., ab.; (10) Halictus lerouxii Lep. ♂♀, s., ab.; (11) H. ligatus Say ♂♀, s.; (12) H. fasciatus Nyl. ♂♀, s.; (13) H. pilosus Sm. ♀, c. p.; (14) H. confusus Sm. ♀, c. p., ab.

Diptera—*Syrphidae:* (15) Allograpta obliqua Say, f. p.; (16) Mesograpta marginata Say, f. p.; (17) Sphærophoria cylindrica Say, f. p.; (18) Eristalis tenax L., s. and f. p.; (19) Helophilus laetus Lw., f. p.; (20) Tropidia quadrata Say, s., freq.; (21) Syritta pipiens L., f. p.

Lepidoptera — *Rhopalocera:* (22) Pieris rapae L.; (23) Phyciodes nycteis D.-H.; (24) Lycaena pseudargiolus B.-L.; (25) Pamphila metacomet Harr.; (26) Pholisora catullus F.—all s.

VERBENA STRICTA Vent.—The plant is quite common. The stem rises from 5 to 10 dm. and bears numerous erect spikes of blue flowers.

The corolla tube rises directly upward, bending outward above and joining the vertically expanded border, which is five-lobed and somewhat two-lipped, expanding from 6 to 12 mm. The tube is about 5 mm. long, is quite narrow and is closed at the mouth by a dense circle of hairs.

The flowers appear homogamous and I see nothing to prevent an insect's proboscis from carrying pollen from the anther back to the stigma of the same flower, though if the proboscis is thoroughly dusted with pollen from another flower, cross-pollination may be more likely.

I have found the flowers in bloom from June 15 to Sept. 16. On nine days, July 9—Aug. 7, I observed the following insects sucking the nectar:—

Hymenoptera—*Apidae*: (1) Apis mellifica L. ☿; (2) Bombus virginicus Oliv. ♂; (3) Melissodes aurigenia Cr. ♂; (4) M. perplexa Cr. ♂♀, ab.; (5) Ceratina dupla Say ♀; (6) Epeolus mercatus F. ♂; *Sphecidae*: (7) Ammophila procera Klug.

Lepidoptera—*Rhopalocera*: (8) Pieris protodice B.-L.; (9) P. rapae L.; (10) Danais archippus F.; (11) Pamphila peckius Kby.; (12) P. cernes B.-L.; (13) Pholisora catullus F.; (14) P. hayhurstii Edw.; (15) Eudamus tityrus F.

Diptera—*Bombylidae*: (16) Exoprosopa fasciata Mcq. ab.; *Conopidae*: (17) Stylogaster neglecta Will.; *Syrphidae*: (18) Eristalis tenax L.

VERBENA HASTATA L.—This plant is less abundant than the last, grows taller and bears small spikes and smaller blue flowers.

The border is 3 to 5 mm. across and the tube 3 or 4 mm. in length.

I have found it in bloom from July 12 to Sep. 23. On 8 days, July 12—Sept. 7, the following insects were observed visiting the flowers for nectar:—

Hymenoptera—*Apidae*: (1) Apis mellifica L. ☿, ab.; (2) Bombus americanorum F. ♂; (3) B. separatus Cr. ☿; (4) Epeolus remigatus F.; *Andrenidae*: (5) Agapostemon radiatus Say ♂; (6) Augochlora pura Say ♂, ab.; (7) Halictus lerouxii Lep. ♂♀; (8) H. fasciatus Nyl. ♂, ab.; (9) H. zephyrus Sm. ♂; *Sphecidae*: (10) Ammophila pictipennis Walsh.

Lepidoptera—*Rhopalocera*: (11) Pieris protodice B.-L.; (12) Pholisora catullus F.; (13) Eudamus tityrus F.

Diptera—*Bombylidae*: (14) Systoechus vulgaris Lw.; (15) Exoprosopa fasciata Mcq., ab.

VERBENA URTICAEFOLIA L.—The flowers are white, much smaller than in the preceding, and are arranged in long loose spikes. Blooms from June 29 to Sept 7, or later. On 8 days July 11—Aug. 29, I observed the following insects, all sucking:—

Hymenoptera—*Apidae*: (1) Apis mellifica L. ☿; (2) Bombus americanorum F. ♂☿; *Andrenidae*: (3) Augochlora pura Say ♂; (4) Halictus ligatus Say ♀; (5) H. confusus Sm. ♀.

Diptera—*Empidae*: (6) Empis clausa Rob. (MS.); *Conopidae*: (7) Stylogaster neglecta Will.; *Syrphidae*: (8) Mesograpta geminata Say; (9) Sphaerophoria cylindrica Say; (10) Syritta pipiens L.

Lepidoptera—*Rhopalocera*: (11) Pieris protodice B.-L.; (12) P. rapae L.

PHRYMA LEPTOSTACHYA L.—The plant grows in damp woods and is not very common. I have found it in bloom from July 10 to Sept. 3. The stem rises about 6 dm. high and bears several branches terminating in slender spikes, which commonly show but two flowers open at a time.

The flower and its three-lobed lower lip project horizontally, the short, slightly notched upper lip diverging in an upward direction. The corolla is white, tinged with pinkish, the upper lip being almost entirely pink. It measures 8 mm. in length, its tube 5 mm., the lower lip 4 mm. in width. The lower wall of the corolla is strongly infolded forming a sort of palate which presents on each side a ridge provided with numerous stiff hairs. This structure narrows the entrance so as to exclude short tongues and to require long tongues to touch the anthers and stigma. Small bees can force their heads into the tubes by forcing down the palate. The flowers are strongly proterandrous, and are visited by *Augochlora pura* Say ♂.

PHYTOLACCA DECANDRA L.—The stems of this common plant rise 2 m. or more, are much branched and bear numerous racemes of small whitish flowers. The five ovate, white sepals are incurved but expand so that the flower measures about 5 mm. across.

The flowers are proterandrous with a homogamous stage. Cross-fertilization between flowers of the same or of distinct plants may occur, and even self-pollination may occur by in-

sect aid. In absence of insects spontaneous self-fertilization may readily take place.

The nectar is exposed. The flowers are visited by short-tongued Hymenoptera and Diptera, especially species of Halictus. I have found the plant in bloom from June 14 to Oct. 15. On July 17 and 23 I observed the following visitors:—

Hymenoptera—*Apidae*: (1) Apis mellifica L. ☿, s.; *Andrenidae*: (2) Halictus ligatus Say ♂, s.; (3) H. fasciatus Nyl. ♂, s.; (4) H. confusus Sm. ♀, s. and c. p., ab.; (5) H. zephyrus Sm. ♀, s.; (6) H. stultus Cr. ♂♀, s. and c. p., ab.; *Vespidae*: (7) Polistes metricus Say, s.; *Pompilidae*: (8) Priocnemis fulvicornis Cr., s.

Diptera—*Empidae*: (9) Empis clausa Rob. (MS.) s.; *Syrphidae*: (10) Mesograpta geminata Say, s.; (11) Syritta pipiens L., s., ab.; *Tachinidae*: (12) Jurinia apicifera Wlk. s.

Hypoxis erecta L.—This plant is quite common in prairies and woods. The scapes, generally one to each plant, rise one or two dm., usually exposing only one open flower at a time. The flowers are yellow, the lanceolate divisions expanding horizontally from 12 to 25 mm. The six stamens are strongly divergent, the stigma occupying the centre of the circle, so that in absence of insects self-pollination cannot occur, unless it happens after the flowers close.

As a rule, insect visits result in cross-fertilization between distinct plants, but may also result in self-pollination.

The flowers are visited only for pollen, and depend especially upon Halictus. I have found them in bloom from April 28 to June 12. May 19 and 22 I observed as visitors:—

Hymenoptera—*Apidae*: (1) Ceratina dupla Say ♀, ab.; *Andrenidae*: (2) Augochlora pura Say ♀, ab.; (3) Halictus pectoralis Sm. ♀; (4) H. coriaceus Sm. ♀; (5) H. ligatus Say ♀; (6) H. cressonii Rob. ♀; (7) H. stultus Cr. ♀; (8) H. tegularis Rob. ♀; (9) H. anomalus Rob. ♀—all collecting pollen.

Diptera—*Syrphidae*: (10) Mesograpta geminata Say; (11) Sphaerophoria cylindrica Say; *Anthomyidae*: (12) Chortophila sp.

Coleoptera—*Buprestidae*: (13) Acmaeodera culta Web.—all feeding on pollen.

Erythronium albidum Nutt.—This is one of the first flowers of spring, and is quite common. The flower bud ap-

[1]According to Meehan, Proc. Acad. Nat. Sci. Phil. 1890, 272, the flower is spontaneously self-fertilized before opening.

pears with a pair of leaves and rises on a scape only a few centimetres above the ground. Owing to a bend in the scape, the flower looks outward and downward, or directly downward. The divisions of the perianth are white, tinged with purplish exteriorly, and marked with yellow at the base within, especially the three petals, which hold nectar on the bases of their claws. At base the divisions are closely approximated, forming a tube about 15 mm. in length, and making the nectar hard to reach except by insects with long tongues; beyond they are directed outward and downward, or may be expanded horizontally so that the flower measures 65 mm. across, or they may be so strongly reflexed that their tips meet, as in the case of plants growing in rich bottom soil.

The anthers of the three outer, shorter stamens dehisce first. At this time, if an insect come with pollen, it will leave some upon the stigma, which is somewhat in advance of the dehiscent anthers; otherwise, it may effect self-pollination. Cross-fertilization may readily occur at any time, but when the inner anthers dehisce, they may easily leave some of their pollen upon the stigma, since they usually surpass the stigma a little. Accordingly, in absence of insects, I think that self-pollination commonly occurs.

The pendulous position of the flower has the effect of restricting the visitors almost exclusively to bees, since they can readily cling to the stamens and style. The first flowers, which appear before flower insects become common, are visited almost exclusively by hive-bees.

For the attention of insects the plant is in competition with Anemonella thalictroides, Isopyrum biternatum, Sanguinaria Canadensis, Viola palmata, Claytonia Virginica and Dentaria laciniata. Competition with Claytonia is most severe; I have found it difficult to collect the visitors of Erythronium until afternoon, after the flowers of the Claytonia had closed.

I have found the plant in bloom from Mar. 17 to Apr. 22. On 13 days, between Apr. 7 and 19, I saw the flowers visited by:—

Hymenoptera—*Apidae*: (1) Apis mellifica L. ☿, s. and c. p., ab.; (2) Bombus virginicus Oliv. ♀, s., one; (3) Ceratina dupla Say ♂, s.; (4) Osmia atriventris Cr. ♂, s., ab.; (5) O. albiventris Cr. ♂♀, s., ab.; (6) O. lignaria Say ♂, s.; (7) O. latitarsis Cr. ♂, s.; (8) Nomada luteola Lep. ♂, s., ab.; *Andrenidae*: (9) Andrena bicolor F. ♂♀, s., ab.; (10) A. sayi Rob. ♂, s.; (11) A.

erythronii Rob. ♂♀, s. and c. p., ab.; (12) A. mariae Rob. ♀, s.; (13) Halictus lerouxii Lep. ♀, s.; (14) H. fasciatus Nyl. ♀, s.; (15) H. confusus Sm. ♀, s.; (16) Colletes inaequalis Say ♂, s. ab.

Lepidoptera—*Rhopalocera*: (17) Pieris rapae L., s.; (18) Colias philodice Godt., s.; (19) Nisoniades juvenalis F., s.

Diptera—*Bombylidae*: (20) Bombylius fratellus Wd., s., one; *Syrphidae*: (21) Brachypalpus frontosus Lw., f. p., one; *Muscidae*: (22) Lucilia cornicina F., s., not touching stigma.

TRADESCANTIA VIRGINICA L. (smooth form).—The plant is smooth and glaucous with linear leaves, the stems rising 3 to 6 dm. and bearing from one to three umbel-like clusters of flowers, each umbel in turn with from 1 to 5 open flowers. The flowers are blue, expanding 3 or 4 cm., but retaining a shallow, bell-shaped form. The stigma is widely separated from the anthers and somewhat surpasses them. Spontaneous self-pollination is hardly probable while the flower is open. Cross-pollination between flowers of the same plant may occur, but owing to the small number of flowers exposed on one plant at a time, cross-pollination between flowers of distinct plants is much more probable.

The flowers are specially adapted to female bees, and other insects in search of pollen. The hairs on the stamens are foot-holds for the use of bees in collecting pollen.

The plant is in strong competition with Rosa humilis for the attention of pollen-visitors, Tradescantia having the advantage of abundance and Rosa of conspicuousness. But they avoid competition to some extent by dividing the visitors between them, Rosa taking the large ones and Tradescantia the small ones.

I have found it in bloom from May 22 to July 30. The following list of visitors was observed on June 4, 5 and 12:—

Hymenoptera—*Apidae*: (1) Bombus pennsylvanicus DeG. ♀; (2) Bombus separatus Cr. ♀; (3) Synhalonia speciosa Cr. ♀; (4) Ceratina dupla Say ♀; *Andrenidae*: (5) Agapostemon nigricornis F. ♀; (6) Halictus pruinosus Rob. ♀—all c. p.

Diptera—*Syrphidae:* (7) Syrphus ribesii L.; (8) S. americanus Wd.; (9) Allograpta obliqua Say; (10) Mesograpta marginata Say; (11) Sphaerophoria cylindrica Say; (12) Tropidia mamillata Lw.

Coleoptera—*Curculionidae*: (13) Stethobaris sp.—all f. p.

Carlinville, Ill.

57.

[From BOTANICAL GAZETTE, Vol. XVII.]

Flowers and insects. VIII.

CHARLES ROBERTSON.

ISOPYRUM BITERNATUM Torr. & Gray.—The plants grow in damp, rich woods, in small patches, notably about bases of trees. The stem rises a few inches and bears a few-flowered cyme, in which only one or two flowers are open at the same time.

The flowers are white, sometimes with a purplish tinge; they are strongly heliotropic and measure about 14 or 15 mm. across, the five oval petals expanding horizontally. The stamens are numerous, the outer elongating and discharging pollen first. Nectar is probably secreted by the bases of the filaments; insects probe among them with their proboscides, evidently for nectar. The four styles at first overtop the inner stamens, and have receptive stigmas before any of the anthers discharge, so that the flower is female in the first stage.

When the cyme contains two open flowers, one of them is commonly in the male, the other in the female stage. In case of insect visits, the latter is more apt to receive pollen from another stem, but may receive it from the older flower

on the same stem. If the stigmas are not pollinated before the outer anthers begin to dehisce, they might receive pollen from them by insect aid or by the closing of the petals. Later, when the inner anthers discharge, if the stigmas remain unfertilized, they may receive pollen falling from the anthers which now overtop them. But insects are by far the most important agents in effecting self-pollination, which, however, I think is the exception.

The flowers remain open all day and open on two or three successive days. For the attention of insects the plant is in strong competition with a number of plants, most of which have the advantage, especially *Claytonia Virginica*, which is much more abundant and more attractive.

The flower is adapted to short-tongued bees and flies, which come for both honey and pollen. It seems especially attractive to bees of the genus *Halictus;* the list shows all of the early-flying species I have found in my neighborhood, except *H. ligatus* and *confusus*, and more species than I have ever found on any other flower.

I have found the flowers in bloom from March 24 to May 12. On twelve days, between March 26 and April 25, I observed the following visitors:

Hymenoptera—*Apidae:* (1) Apis mellifica L. ☿, s. & c. p., freq.; (2) Bombus americanorum F. ♀, s., one; (3) Synhalonia honesta Cr. ♂, s., one; (4) Ceratina tejonensis Cr. ♂, s.; (5) C. dupla Say ♂, s.; (6) Osmia albiventris Cr. ♂ ♀, s.; (7) Nomada bisignata Say ♂ ♀, s.; *Andrenidae:* (8) Andrena bicolor F. ♂ ♀, s., freq.; (9) A. sayi Rob. ♂ ♀, s.; (10) A. erigeniae Rob. ♂ ♀, s.; (11) A. flavo-clypeata Sm. ♀, c. p.; (12) A. rugosa Rob. ♂ ♀, s.; (13) A. forbesii Rob. ♀, s.; (14) A. claytoniae Rob. ♂, s.; (15) Agapostemon radiatus Say ♀, s.; (16) Augochlora labrosa Say ♀, s.; (17) A. pura Say ♀, s.; (18) Halictus gracilis Rob. ♀, s.; (19) H. 4-maculatus Rob. ♀, s.; (20) H. pectoralis Sm. ♀, s.; (21) H. coriaceus Sm. ♀, s.; (22) H. forbesii Rob. ♀, s.; (23) H. lerouxii Lep. ♀, s. & c. p.; (24) H. fasciatus Nyl. ♀, s. & c. p., ab.; (25) H. cressonii Rob. ♀, s.; (26) H. pilosus Sm. ♀, s.; (27) H. obscurus Rob. ♀, s. & c. p., ab.; (28) H. stultus Cr. ♀, s., c. p., f. p.; (29) H. zephyrus Sm. ♀, s., ab.; (30) H. imitatus Sm. ♀, s., one; (31) Colletes inaequalis Say ♂, s.

Diptera—*Bombylidae:* (32) Bombylius fratellus Wd., s., ab.; *Empidae:* (33) Empis sp., s., one; *Syrphidae:* (34) Chil-

osia capillata Lw.; (35) Melanostoma obscurum Say; (36) Syrphus ribesii L.; (37) S. americanus Wd.; (38) Mesograpta marginata Say; (39) M. geminata Say; (40) Sphaerophoria cylindrica Say; (41) Eristalis dimidiatus Wd.; (42) Helophilus similis Mcq.; (43) Xylota fraudulosa Lw.—all s. & f. p.; *Tachinidae:* (44) Gonia frontosa Say, s.; *Muscidae:* (45) Lucilia cornicina F., s.

Coleoptera—*Coccinellidae:* (46) Megilla maculata DeG., f. p., one; *Chrysomelidae:* (47) Diabrotica vittata F., f. p., one; *Œdemeridae:* (48) Asclera ruficollis Say, f. p.; *Anthicidae:* (49) Corphyra terminalis Say, f. p.

Hemiptera—*Capsidae:* (50) Lygus pratensis L., s., one.

SANGUINARIA CANADENSIS L.—This is a common plant of wide distribution. In my neighborhood, however, it is rather rare; at any rate, I know of but a few stations for it.

Each plant bears a single scape rising about one decimeter and supporting an 8 to 12-petaled, white flower, which expands about 4 or 5 cm. The plants are sometimes collected in little clusters, so that the flowers are made quite conspicuous and must attract insects from a distance. In the morning the petals are expanded horizontally, but in the afternoon they become more erect, preparatory to closing.

The flowers are female in the first stage. On the first day of opening, the large, two-lobed stigma is receptive, while the anthers are still closed. By the time the anthers are beginning to discharge, the stigma has turned brown, its papillae appearing shriveled.

The numerous stamens are of unequal length, the outer being much shorter. The tips of the inner anthers sometimes barely rise as high as the stigma, in which case, provided pollination has not previously occurred, the stigma might receive a little pollen from the surrounding anthers. The pollen is the attraction for insects, although I have seen hive-bees and *Bombylius fratellus* Wd. vainly probing for nectar about the base of the ovary.

The newly opened flowers are smaller and less widely expanded. Insects land upon them, dusting their stigmas before perceiving that the anthers are indehiscent. The result is cross-fertilization between distinct plants.

In competition with *Sanguinaria* are *Anemonella thalic-*

troides, *Isopyrum biternatum*, *Claytonia Virginica*, *Erigenia bulbosa* and *Erythronium albidum*, all of which have the advantage.

The flowers are monopolized by hive-bees, which collect the pollen so effectually that it is very difficult to find out what were the normal visitors of the flower. There is little doubt, however, that the plant originally depended for fertilization mainly upon the aid of bees of the genera *Halictus* and *Andrena* and flies of the family *Syrphidae.*

I have found the flowers in bloom from April 2 to 13. On April 13 I noted the following visitors:

Hymenoptera—*Apidae:* (1) Apis mellifica L. ☿, c. p., ab.; *Andrenidae:* (2) Halictus zephyrus Sm. ♀, c. p.; (3) H. stultus Cr. ♀, c. p.

Diptera—*Syrphidae:* (4) Syrphus sp., f. p.

Coleoptera—*Œdemeridae:* (5) Asclera ruficollis Say, f. p., freq.

I also saw several individuals of *Andrena bicolor* F. ♂ flying about the flowers in search of the female, which is probably a visitor.

At Madison, Wisconsin, May 9, Professor Trelease found the flower visited for pollen by *Andrena bicolor* F. ♀ and *Halictus confusus* Sm. ♀.

BAPTISIA LEUCOPHAEA Nutt.—This plant is rare in my neighborhood; I know of but one station for it, on creek bluffs. The stems rise about a foot from the ground, are diffusely branched and bear large, drooping racemes of handsome, cream-colored flowers.

The calyx tube measures about 5 or 6 mm. and serves to hold the petals so that they can not easily be separated by intruders. The banner runs forward for about 14 mm. when it rises nearly straight upwards. Its blade measures 20 mm. or more in breadth, and is not so strongly reflexed at the sides as in *B. leucantha.* The wings extend forward and conceal the keel. At the base above, the blade is inflected upon a gibbosity upon the base of the keel, with the result that, when a bee lands upon the flower, it depresses both wings and keel.

The stamens are distinct. Since there is is no special opening at the base to admit the bee's tongue, as in the diadel-

phous Papilionaceae, the bee inserts its proboscis between the upper filaments. The filaments are somewhat unequal in length. The anthers dehisce in succession, so that to remove all of the pollen, bees must visit each flower several times. The stigma is situated among the anthers, and I find nothing to prevent self-pollination. The flower has more accessible nectar than in B. leucantha, but on account of its early blooming, it has less need of adaptation to exclude shorter tongues, since it is mostly exposed to *Bombus* females and species of *Synhalonia.*

Osmia latitarsis was the only bee visiting it for both honey and pollen, and there may be an important relation between the flower and the bee, which are both equally rare. I have as yet taken the female of this *Osmia* only on the present flower.

The following list of visitors was observed on May 16 and 19:

Apidae: (1) Bombus separatus Cr. ♀, s.; (2) B. americanorum F. ♀, s.; (3) Synhalonia speciosa Cr. ♀, s.; (4) Osmia latitarsis Cr. ♀, s. & c. p.

TRIFOLIUM PRATENSE L.—("Adv. from Eu.")—I have been much interested in observing how frequently this well-known bumble-bee flower is visited by Lepidoptera. It is a common thing for bee-flowers to be visited to some extent by butter-flies, but this seems to me to be an unusual case. In Germany, Müller found it visited by 8 Lepidoptera in a list of 39 insects, while in Illinois I have found it visited by 13 species in a list of 20. Our flowers are exposed to a richer butterfly-fauna, so that we may expect to find a larger proportion of butterflies upon them, and the differences between bee and butterfly-flowers may not be so well indicated in the lists of visitors.

But while butterflies may sometimes effect cross-fertilization of the red clover, they are of doubtful value, if not injurious. Bumble-bees depress the keel so that their heads and proboscides are well dusted with pollen. But butterflies can insert their thin tongues without depressing the keel, and, even if they get a little pollen on their thin proboscides, it is apt to be wiped off by the closely approximated tips of the petals, which close the mouth of the flower.

I have found it in bloom from April 26 to Nov. 4. On 15 days, May 10 to Sept. 11, I noted as visitors:

Hymenoptera—*Apidae:* (1) Bombus ridingsii Cr. ♂, once; (2) B. separatus Cr. ♂ ♀ ☿, ab.; (3) B. pennsylvanicus DeG. ♀ ☿, ab.; (4) B. americanorum F. ♂ ♀ ☿, very ab.; (5) B. vagans Sm. ☿, s., one; (6) Anthophora abrupta Say ♂ ♀.

Lepidoptera—*Rhopalocera:* (7) Danais archippus F.; (8) Argynnis cybele F.; (9) Pyrameis atalanta L.; (10) P. huntera F.; (11) P. cardui L.; (12) Lycaena comyntas Godt.; (13) Papilio cresphontes Cram.; (14) Pieris rapae L.; (15) Callidryas eubule L.; (16) Pamphila peckius Kby.; (17) P. cernes B.-L.; (18) Eudamus tityrus F.; *Sphingidae:* (19) Hemaris axillaris G.-R.

Birds—*Trochilidae:* (20) Trochilus colubris L., thrice.

The following table gives the visitors which have been observed sucking the flowers in the normal way:

REGION.	Bombus.	Anthophora.	Eucera.	Anthidium.	Megachile.	Osmia.	Bombylius.	Lepidoptera	Trochilus.	Total.
1. In Low Germany—Müller,[1]...	12	1	1	1	1	1	1	6	..	25
2. In the Pyrenees—MacLeod,[2]..	6	1	..	..	..	..	1	11	..	19
3. In Illinois..................	5	1	..	..	..	..	..	13	1	20

HEUCHERA HISPIDA Ph.—Each plant of this common species bears several scapes, which rise 6 to 9 dm., and bear long panicles of greenish flowers.

The calyx is oblique, being quite gibbous on the lower side. It measures about 6 mm. in length, the lobes being directed forward and a little inward and the petals filling the intervals, so that the effect is much the same as if the parts were united to their tips. The tube is very broad, measuring about 4 mm. wide, so that it readily admits the head and thorax of a bee.

The stamens lengthen and discharge pollen in succession, beginning with the upper one. Accordingly, to collect all of the pollen, the flower must be visited several times.

The flowers are proterogynous[3] with long-lived stigmas, and are remarkable for being visited exclusively by a species

[1] Fertilization of Flowers. [2] Pyreneënbloemen. [3] Müller, Fertilization of Flowers, 243.

of *Colletes*, *C. heucherae* Rob., the females coming for honey and pollen, and the males for honey and in search of the females.

It blooms from May 11 to June 29.

LYTHRUM ALATUM Ph.—The plants are common in wet places. The stems grow 4 or 5 dm. high, are much branched and bear many loose racemes of purple flowers. The six petals are each marked with a reddish line leading to the base. They expand so that the flowers measure 15 mm. across.

The dimorphism of the flowers was first recorded by Halsted in the Bulletin of the Iowa Agricultural College, 1888. In the short-styled form the stigma reaches the throat of the calyx tube, and the stamens are exserted from 3 to 4 mm. In the long-styled form the stigma is exserted about 3 mm., and the anthers only reach the throat. In this form the stamens are variable, sometimes giving an appearance of trimorphism; but the unequal length seems only to prevent crowding of the anthers in the narrow tube.

The plants often grow in large patches, which renders them quite conspicuous, and very attractive to insects. The calyx-tube is narrow and measures 5 or 6 mm. in length, which restricts the visitors to long tongues. The principal visitors are butterflies. On 12 days, June 18—Aug. 18, the following list was observed:

Hymenoptera—*Apidae:* (1) Bombus virginicus Oliv. ☿, s. & c. p., freq.; (2) Melissodes bimaculata Lep. ♂, s., freq.; (3) Megachile petulans Cr. ♂, s.; (4) M. brevis Say, ♂ ♀, s., freq.; (5) Coelioxys 8-dentata Say ♀, s.; (6) Epeolus lunatus Say ♀, s.; *Andrenidae:* (7) Agapostemon nigricornis F. ♀, s.

Lepidoptera—*Rhopalocera:* (8) Pieris protodice B.-L.; (9) P. rapae L.; (10) Colias philodice Godt.; (11) Pyrameis cardui L.; (12) Chrysophanus thoe B.-L.; (13) Pamphila peckius Kby.; (14) P. cernes B.-L.; (15) Pholisora catullus F.—all s.

Diptera—*Bombylidae:* (16) Systoechus vulgaris Lw.; (17) Exoprosopa fasciata Mcq.; (18) E. fascipennis Say—all s.; *Syrphidae:* (19) Helophilus latifrons Lw.; (20) Tropidia quadrata Say—both f. p.

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Flowers and insects. IX.

CHARLES ROBERTSON.

Hydrangea arborescens L.[1]—The stems rise from one to several feet high and bear flat-topped compound cymes measuring seven to ten centimeters across. Each cyme is commonly surrounded by a few large sterile flowers which render it much more conspicuous. These sterile flowers are remarkably persistent, retaining their form throughout the winter, though they lose their color.

The entire fertile flower with its pedicel is white. The petals are small and soon fall. The stamens, which are commonly ten, with their large anthers, are the most conspicuous part of the flower. When dehiscent they far overtop the stigmas. Nectar is secreted on the base of the styles, though pollen is the chief attraction.

The flowers are homogamous, but are visited by so many bees and flies that frequent cross-pollination is inevitable. Insects may also effect self-pollination, or spontaneous self-pollination may occur by the pollen falling upon the stigmas.

The plants are common on creek banks and were observed in bloom from June 24th to July 23rd. The following list of visitors was observed June 27th and 30th:

Hymenoptera—*Apidæ:* (1) Bombus separatus Cr. ☿, c. p., ab.; (2) B. americanorum F. ♀, c. p.; (3) Ceratina dupla Say ♀, s. and c. p.; (4) Heriades carinatum Cr. ♀, c. p.; *Andrenidæ:* (5) Augochlora labrosa Say ♀, s. and c. p.; (6) Halictus pectoralis Sm. ♂♀, s. and c. p.; (7) H. similis Sm. ♀, s. and c. p.; (8) H. truncatus Rob. (MS.) ♀, s. and c. p.; (9) H. fasciatus Nyl. ♀, c. p.; (10) H. confusus Sm. ♀, s. and c. p., ab.; (11) H. stultus Cr. ♀, s. and c. p., ab.; (12) Prosopis affinis Sm. ♂♀, s. and f. p., ab.; *Crabronidæ:* (13) Crabro interruptus Lep., s.

[1]See Meehan: Contributions to the life histories of plants, No. II, Proc. Acad. Nat. Sci., Phil., 1888.

Diptera—*Empidæ:* (14) Empis clausa Rob. (MS.) s., ab.; *Conopidæ:* (15) Oncomyia loraria Lw., s., freq.; (16) Stylogaster biannulata Say, s.; *Syrphidæ:* (17) Paragus tibialis Fll., s. and f. p.; (18) Syrphus americanus Wd., s. and f. p.; (19) Allograpta obliqua Say, s. and f. p.; (20) Mesograpta geminata Say, s. and f. p.; (21) Sphaerophoria cylindrica Say, s. and f. p.; (22) Eristalis tenax L., s.; (23) Syritta pipiens L., s. and f. p.; *Tachinidæ:* (24) Jurinia apicifera Wlk., s.; *Muscidæ:* (25) Graphomyia sp., s.; (26) Musca domestica L., s.; (27) Lucilia cornicina F., s.

Coleoptera—*Cerambycidæ:* (28) Euderces picipes F., s. and f. p.; (29) Typocerus velutinus Oliv., s. and f. p.; *Mordellidæ:* (30) Mordella marginata Melsh., s., ab.; (31) Mordellistena sp., s., ab.; (32) M. ornata Melsh.

Lepidoptera—*Hesperidæ:* (33) Eudamus tityrus F., s.; *Pyromorphidae:* (34) Harrisina americana Harr., s. (determined by Prof. G. H. French).

PHILADELPHUS GRANDIFLORUS Willd.[2]—This plant occurs in my neighborhood only in cultivation. I have found it visited very abundantly by *Heriades philadelphi* Rob. ♂♀.

RIBES GRACILE Michx.—The Missouri gooseberry is common in woods, blooming from April 15th to May 3d. The bushes are sometimes collected in large clumps, the flowers being abundant enough to fully repay the attention of insects.

The greenish flowers grow in axillary clusters of two or three. The pendulous position and the characters of the flower indicate an adaptation to bees. The calyx tube is two or three mm. long. The oblong lobes, which measure six or seven mm. in length, are strongly reflexed. With the petals they form footholds for the bees to cling to, and with their purplish bases, are the most conspicuous parts of the flower. The five stamens are exserted 12 mm. or more beyond the calyx-tube, and are closely approximated. Five pinkish petals about 2 mm. long are pressed against the filaments, closing as far as they go the intervals between them.

The flowers are proterandrous. When receptive, the stigma surpasses the anthers a little. The anthers sometimes retain pollen after the stigma becomes receptive, but self-pollination is hardly possible, unless it is brought about by insect aid. Everything points to cross-pollination between separate flowers.

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[2]On P. coronarius see Müller: Fertilization of Flowers, 248.

The nectar is secreted by an epigynous disk and is held in place by the abundant hairs on the base of the style and on the wall of the calyx-tube. To reach it bees must insert their proboscides between the filaments beyond the tips of the petals. For this purpose a proboscis at least 4 mm. long seems to be needed.

The flowers are especially adapted to bumblebee females, the only sex of Bombus flying while the flowers are in bloom. These bees are the only ones which, while sucking, invariably touch the anthers and stigmas. They cling to the petals and sepals, and the anthers and stigmas strike them about the base of the ventral surface of the abdomen. Of these the following were noted visiting the flowers for nectar:

(1) Bombus separatus Cr. ♀; (2) B. vagans Sm. ♀; (3) B. virginicus Oliv. ♀, ab.; (4) B. americanorum F. ♀, very ab.

Besides bumblebees there occur as frequent visitors a number of species of bees which insert their proboscides between the filaments and are able to reach the nectar, but are so small that they never, or rarely, touch the anthers and stigmas, and so are to be regarded as mere intruders. Such are:

Apidæ: (1) Apis mellifica L. ☿, s. and c. p., ab.; (2) Osmia albiventris Cr. ♂, s.; (3) O. lignaria Say ♂, s.; (4) Nomada luteola Lep. ♂♀, s.; *Andrenidæ:* (5) Agapostemon radiatus Say ♀, s.; (6) Augochlora pura Say ♀, s.; (7) A. lucidula Sm. ♀, s.; (8) Andrena sayi Rob. ♂♀, s., ab.; (9) A. pruni Rob. ♂♀, s.; (10) A. rugosa Rob. ♂, s.; (11) Halictus gracilis Rob. ♀, f. p., ab.; (12) H. coriaceus Sm. ♀, s.; (13) H. lerouxii Lep. ♀, s. and f. p.; (14) H. cressonii Rob. ♀; (15) H. zephyrus Sm. ♀; (16) H. imitatus Sm. ♀; (17) H. stultus Cr. ♀; (18) Colletes inaequalis Say ♂♀, s.

Diptera—*Empidæ:* (19) Empis sp., s.

The visitors were observed on nine days between April 18th and 29th.

LUDWIGIA ALTERNIFOLIA L.—The yellow flowers are rather conspicuous. Honey collects in round drops in four pits on the sides of the ovary between the bases of the filaments. The pits are slightly protected above by a fringe of hairs. Some of the anthers dehisce when fairly in contact with the stigma, but much of the stigma remains clear, and so can receive pollen brought by insects. *Bombus americanorum* F. ☿, was seen visiting the flowers for nectar, and *Halictus stultus* Cr. ♀, visiting them for pollen. The flowers were seen in bloom from July 19th to Aug. 10th.

LUDWIGIA POLYCARPA S. & P.—The flowers are wholly devoid of entomophilous characters. The petals are wanting, and there is no nectar. The four stamens bend inwards, bringing the anthers in contact with the stigma. Spontaneous self-pollination is therefore a regular occurrence.

ŒNOTHERA BIENNIS L.[3]—The following list was observed on Aug. 26th and 29th:

Apidæ: (1) Bombus americanorum F. ♂ ☿, s. and c. p., freq.; (2) Melissodes bimaculata Lep. ♀, c. p.; (3) M. obliqua Say ♀, c. p.

Trochilidæ: (4) Trochilus colubris L., s., two.

I have found the flowers in bloom from July 22nd to Oct. 15th.

Müller found it visited by one Macroglossa, three Bombus, one Apis, one Colletes, one Panurgus, three Eristalis.

ŒNOTHERA FRUTICOSA L.—This is a common plant, growing on prairies. The stem rises a few dm. and generally bears one, sometimes two or three, yellow flowers which expand 4 or 5 cm. Eight large versatile anthers supply pollen, which is an attractive character of the flower. The stigma surpasses the anthers so that self-pollination is impossible without insect aid. As a rule, the stigma is inclined to the lower side in such a position that it readily strikes the ventral surface of a bumble-bee settling upon the flower. If insects come with pollen, they may effect cross-pollination, otherwise they may effect self-pollination. When two or more flowers are expanded at the same time cross-pollination between flowers of the same plant may occur. In the usual case in which the stem exposes only one open flower at a time cross-pollination between distinct plants is the rule.

The tube measures 14–20 mm., so that it can only be drained by the largest bees, but shorter-tongued bees are sometimes able to reach a little of the nectar which rises in the tube.

Besides the long-tongued insects which visit the flower for nectar, there are many species, especially Andrenidae and Syrphidae, which come only for pollen. Accordingly the flower must be regarded as adapted to both sets of insects.

The flowers bloom from May 24th to June 29th. On 7 days, between May 28th and June 19th, the following list was observed:

[3] See Müller: Fertilization of Flowers, 246.

Hymenoptera—*Apidæ:* (1) Bombus americanorum F. ♀, s. and c. p., ab.; (2) Synhalonia speciosa Cr. ♀, s. and c. p.; (3) Ceratina dupla Say ♀, c. p.; (4) Megachile brevis Say ♂♀, s.; (5) M. montivaga Cr. ♂♀, s. and c. p., ab.; (6) Alcidamea producta Cr. ♀, c. p.; *Andrenidæ:* (7) Agapostemon nigricornis F. ♀, c. p., ab.; (8) Augochlora pura Say ♀, c. p., freq.; (9) Halictus pectoralis Sm. ♀, c. p.; (10) H. parallelus Say ♀, c. p.; (11) H. lerouxii Lep. ♀, c. p.; (12) H. ligatus Say ♀, c. p.; (13) H. fasciatus Nyl. ♀, c. p.; (14) H. albipennis Rob. ♀, c. p.; (15) H. confusus Sm. ♀, c. p.

Diptera—*Syrphidæ:* (16) Syrphus americanus Wd., f. p.; (17) Sphaerophoria cylindrica Say, f. p.; (18) Eristalis dimidiatus Wd., f. p.; (19) E. latifrons Lw., f. p.; (20) Tropidia mamillata Lw., f. p.; *Tachinidæ:* (21) Cistogaster pallasii Twns., f. p.

Lepidoptera—*Rhopalocera:* (22) Pieris protodice B.-L.; (23) Pamphila peckius Kby.; (24) P. cernes B.-L.—all s.

Coleoptera—*Chrysomelidæ:* (25) Diabrotica 12-punctata Oliv., f. p.; *Curculionidæ:* (26) Centrinus scutellum album Say, f. p., ab.

GAURA BIENNIS L.[4]—This common species was observed in bloom from August 4th to October 24th. The stems grow one or two metres high, bear numerous flowers, and are often collected in large patches.

The flowers are white. The four petals are all turned to the upper side of the flower, and the stamens, which are directed horizontally, afford a landing place to the visiting insects. The stigma is in advance of the anthers and touches the bee before them. The calyx tube is about 10 mm. long. The flowers are adapted to long-tongued bees, but on account of the exposure of the anthers are also visited for pollen by other insects. The list was observed on 5 days, between Aug. 23d and Sept. 10th.

Hymenoptera—*Apidæ:* (1) Apis mellifica L. ☿, c. p.; (2) Bombus americanorum F. ☿, s. and c. p., ab.; (3) B. virginicus Oliv. ☿, c. p.; (4) Melissodes bimaculata Lep. ♀, s. and c. p.; *Andrenidæ:* (5) Halictus confusus Sm. ♀, c. p.

Diptera—*Syrphidæ:* (6) Syrphus americanus Wd., f. p.

CIRCÆA LUTETIANA L.—The flower is described and figured by Müller in the Fertilization of Flowers, 265. Müller saw

[4]See Sprengel; 223, Pl. XIII, 12, 14, 15. See G. Lindheimeri, Goodale & Sprague: Wild flowers, Pl. XXIII.

the flowers visited by: *Syrphidæ:* (1) Baccha elongata F.; (2) Ascia podagrica F.; (3) Melanostoma mellina L.; *Muscidæ:* (4) Musca domestica L.; (5) Anthomyia sp.

July 2nd, 4th and 10th I saw the flowers visited by:

Hymenoptera—*Andrenidæ* (1) Augochlora pura Say ♀, s. and c. p., freq.; (2) Halictus 4-maculatus Rob. ♂ ♀, s. and c. p., ab.; (3) H. confusus Sm. ♀, s. and c. p.; (4) H. pectinatus Rob. ♀, c. p.; *Chalcididæ:* (5) Spilochalcis debilis Say, s.

Diptera—*Bombylidæ:* (6) sp.; (7) Hemipenthes sinuosa Wd., f. p.; *Syrphidæ:* (8) Allograpta obliqua Say; (9) Mesograpta marginata Say; (10) M. geminata Say—all sucking.

MOLLUGO VERTICILLATA L.[5]—"An immigrant from farther south."—The plants are much branched, the branches lying flat on the ground and bearing small, white flowers, which are numerous but not enough to form conspicuous clusters.

The flowers are erect, expand horizontally and measure about 4 mm. across. The three anthers rise to the level of the three stigmas and alternate with them.

In case of insect visits, cross-pollination between flowers of the same or of distinct plants may readily occur. In case insects fail, spontaneous self-pollination may take place by the anthers coming in contact with the stigmas.

Although the flowers are very inconspicuous, they are attractive to numerous small insects, mainly *Halictus*, on account of their easily accessible nectar.

I have found the plant in bloom from July 1st to Oct. 12th. On three days, July 16th, and Aug. 11th and 21st, the following list of visitors was observed:

Hymenoptera—*Andrenidæ:* (1) Halictus fasciatus Nyl. ♂, s.; (2) H. pilosus Sm. ♂, s.; (3) H. confusus Sm. ♂ ♀, s. and c. p. freq.; (4) H. tegularis Rob. ♂ ♀, s.; (5) H. stultus Cr. ♀, s. and c. p. freq.; *Philanthidæ:* (6) Cerceris finitima Cr., s., freq.

Diptera—*Conopidæ:* (7) Zodion nanellum Lw.; *Syrphidæ:* (8) Paragus tibialis Fll.; (9) Pipiza pulchella Will.; (10) Mesograpta marginata Say; *Sarcophagidæ:* (11) Sarcophaga sp.; *Muscidæ:* (12) Lucilia cornicina F.—all sucking.

Coleopetra—*Malachidæ:* (13) Collops 4-maculatus F., s.

SAMBUCUS CANADENSIS L.—The stems grow three or four meters high, and are commonly collected in clumps, which at blooming time are fairly white with the large flat-topped cymes. The flowers expand 4 or 5 mm. They are homo-

[5] On this plant see Meehan; Torrey Bulletin, XIV, 218.

gamous. The stamens are so strongly divergent that spontaneous self-pollination is impossible. Nectar is wanting, the object of insect visits being the pollen. The plant is common and was observed in bloom from June 15th to July 25th. June 17th, 23d and 24th, the following visitors were noted:

Hymenoptera—*Apidæ:* (1) Apis mellifica L. ☿, freq., (2) Ceratina dupla Say ♀; *Andrenidæ:* (3) Halictus zephyrus Sm. ♀, ab.; (4) H. confusus Sm. ♀, ab.; (5) H. stultus Cr. ♀, ab.—all collecting pollen.

Diptera—*Bombylidæ:* (6) sp.; (7) Hemipenthes sinuosa Wd.; *Syrphidæ:* (8) Chrysogaster nitida Wd., ab.; (9) Syrphus ribesii L., freq.; (10) Allograpta obliqua Say, freq.; (11) Mesograpta marginata Say; (12) Eristalis dimidiatus Wd.; *Muscidæ:* (13) Lucilia cornicina F.; *Anthomyidæ:* (14, 15) Chortophila spp.—all feeding on pollen.

Coleoptera—*Dermestidæ:* (16) Attagenus piceus Oliv.; *Malachidæ:* (17) Anthocomus erichsoni Lec.; *Cerambycidæ:* (18) Euderces picipes F.; *Mordellidæ:* (19) Pentaria trifasciata Melsh.—all feeding on pollen.

Houstonia purpurea L., var. calycosa Gr.—This common plant grows in tufts or clusters which are rendered quite conspicuous by the abundant white flowers, the stems rising about 2 dm.

The corolla is funnel-form, measuring about 8 mm. in length, its border also expanding about 8 mm. The tube is about 7 mm. Below it is narrowed for about 4 mm. Small bees can insert their heads as far as 3 mm., when they need a proboscis 4 mm. to drain the sweets. The narrow part of the tube is obstructed in both forms by abundant hairs, in the long-styled form by the anthers and in the short-styled form by the stigma. The anthers of the short-styled form are in the angles of the mouth of the tube, the stigma of the long-styled form being more strongly exserted.

The anthers of the long-styled form apply their pollen to the proboscides of the visitors. The anthers of the short-styled form dust their pollen indefinitely upon all parts of the insects. Accordingly the long-styled form has a larger stigma.

The flowers are adapted to small bees, like *Ceratina*, *Calliopsis* and *Halictus*, but are also visited by flies, beetles and butterflies. Butterflies, however, are only adapted to pollinate the short-styled form, since they can suck this form with-

out touching the anthers. A monopoly of the flowers by them would probably result in a functional diœcism, characterized by long-styled staminate and short-styled pistillate flowers.

The plant blooms from May 19th to June 30th. The list was observed on 6 days, between May 25th and June 12th.

Hymenoptera—*Apidæ:* (1) Apis mellifica L. ☿, s.; (2) Synhalonia honesta Cr. ♂, s.; (3) Ceratina dupla Say ♂♀, s. and c. p., ab.; (4) Heriades carinatum Cr. ♂ s.; (5) Calliopsis andreniformis Sm. ♂♀, s. and c. p., ab.; *Andrenidæ:* (6) Augochlora pura Say ♀, s. and c. p.; (7) Halictus ligatus Say, ♀, s.; (8) H. pilosus Sm. ♀, s. and c. p.; (9) H. confusus Sm. ♀, s. and c. p.; (10) H. albipennis Rob. ♀, s. and c. p.

Diptera—*Syrphidæ:* (11) Paragus bicolor F., s.; (12) P. tibialis Fll., s.; (13) Mesograpta marginata Say, s.; (14) Sphaerophoria cylindrica Say, s. and f. p., ab.; (15) Syritta pipiens L., s.

Lepidoptera—*Rhopalocera:* (16) Pieris protodice B.-L.; (17) Chryophanus thoe B.-L.; (18) Ancyloxypha numitor F., ab.; (19) Pholisora catullus F. —all sucking.

Coleoptera—*Scarabæidæ:* (20) Trichius piger F., s., ab.; *Curculionidæ:* (21) Centrinus scutellum-album Say, s.; (22) Stethobaris sp., s.

Carlinville, Ill.

7³

[FROM BOTANICAL GAZETTE, Vol. XVIII.]

Flowers and insects. X.

CHARLES ROBERTSON.

STEIRONEMA LANCEOLATUM Gray.—The plants are commonly collected in small patches. They grow 3 or 4^{dm} high, and expose a few yellow flowers with reddish-purple centers. The flowers look outwards and a little downwards, and expand from 20 to 25^{mm}. In the bud each corolla lobe enfolds an anther. When the flower expands, the lobes carry the enclosed anthers with them, holding them while the stigma is receptive and is exposed to insects—a fact to which my attention was first called by Professor Pammel. After the anthers are released, the styles are commonly found bent outwards, out of the way of the falling pollen. Sprengel supposed that flowers of *Lysimachia quadrifolia* were nectar bearing, but failed to find nectar. He, and Müller also, failed to find honey in flowers of *L. vulgaris*. According to Kirchner nectar is wanting in *L. nemorum* as well as in *L. nummularia*. I have been uncertain in regard to the occurrence of honey in Steironema, but the visits of male bees seem to indicate its presence, although these insects might search for it in vain. They commonly fly about the flowers to find the females, not trying to find honey.

I have noted the flowers in bloom from June 20th to July 12th. As far as I have observed, they are visited for honey and pollen only by *Macropis steironematis* Rob. ♂♀.

STEIRONEMA LONGIFOLIUM Gray.—This plant resembles the preceding, but grows somewhat taller and bears a greater profusion of flowers. The flowers are without purplish centers. They appear more homogamous, the anthers being more readily released by the lobes, and the style not being bent aside. The flowers were noted in bloom from July 26th to August 23d. The only visitors observed were *Macropis steironematis* Rob. ♂♀, c. p., and perhaps s., abundant, and *Halictus confusus* Sm. ♀, c. p., once.

The flowers of Lysimachia and Steironema seem to hold, as regards their economy, an important mutual relation with bees of the genus *Macropis*. In the "Fertilization of Flowers" Müller states that he found the females of *Macropis labiata*, as a rule, only on flowers of *Lysimachia vulgaris*, and the only other cases cited in that work of the occurrence of *Macropis* on flowers are the visits of the males to flowers of *Œnanthe fistulosa*, *Rhamnus Frangula*, *Melilotus alba* and *Rubus fruticosus*. The other insects observed by Müller on *L. vulgaris* were rare and their visits evidently have no significance. In the Entomologist's Monthly Magazine, XVII, 31–35, Mr. W. H. Patton states that in Connecticut he found *Macropis ciliata* ♀ on flowers of *Steironema ciliatum*, *Rhus glabra*, *R. typhina* and *Archangelica hirsuta*, but says nothing about them collecting pollen. The male was captured on flowers of *Rubus villosus* and *Cornus paniculata*. *M. patellata* ♂ was taken on flowers of either *Cicuta* or *Rhus* and on *Steironema ciliatum*. I have taken *M. steironematis* on flowers of *Ceanothus Americanus*, *Apocynum cannabinum* and *Melilotus alba*, but I have never seen the female collecting any pollen except that of Steironema. We have here a case which as far as mutual dependence goes bears a strong resemblance to the case of Yucca and Pronuba.

FRASERA CAROLINENSIS Walt.—The plants are frequent on rich hillsides, blooming, as far as observed, from May 26th to June 12th. The stem grows as high as two meters, and bears an immense panicle of pale-greenish flowers, which measure about 35^{mm} across.

The flowers are pendulous. The four lanceolate petals expand horizontally. They have whitish bases and greenish tips. On the middle of each petal, about 3^{mm} from its base, is situated a peculiar nectariferous depression, which is oval in outline, about 4^{mm} long by 3^{mm} wide and 1^{mm} deep. This is sur-

rounded by a dense circle of hairs, which form a crest over the cavity and completely conceal the nectar. Some of the hairs are bent downwards, and their tips are turned into the cavity. Besides concealing the nectar from small short-tongued intruders which could not effect pollination, the hairs serve as foot-holds for insects to cling to when extracting the sweets. About this nectary the petals are purple-dotted—the dots serving as path-finders.

Four divergent stamens about 13^{mm} long alternate with the petals, while the stigma occupies the center of the circle. Self-pollination is prevented by the strong proterandry.

When an insect clings to one of the crested nectaries, its body is fairly certain to touch the anthers on that side, as well as the stigma. The size of the flower, however, indicates that the insect, in order to do this, must be of large size. I expected to see the flowers visited by bumble-bees, which, after all, may prove to be the principal visitors, but after watching them on June 10th and 11th the only insect observed sucking, which could effect pollination, was *Polistes metricus* Say ♀. It clings to the stamens and style with its posterior legs and can readily strike the anthers and stigma. *Halictus coriaceus* Sm. ♀ visits the flower for honey and pollen, but is too small to do any good.

ELLISIA NYCTELEA L.—The plant is common, rises about 2^{dm}, is scattered in thin patches, and is commonly rendered quite inconspicuous by the surrounding vegetation. The rather diffuse branches bear only a few flowers, which bloom in succession, so that, in their visits, insects are as likely to pass between flowers of distinct plants as from flower to flower on the same plant. The flowers vary in position from erect to pendulous, the calyx lobes, which equal the corolla in length, often concealing it from view.

The corolla measures about 4 or 5^{mm} in length and expands about 6^{mm}. The tube is about 4^{mm} long and is as wide as 2^{mm}, so that it readily admits the head and thorax of small bees. The border is turned out nearly horizontally and is divided into five rounded lobes. With the exception of three to five purplish dots on the middle of the lobes, the color is white. A few hairs on the inner wall of the corolla tube seem to have little significance.

Five stamens alternate with the corolla lobes and bend to the center of the flower, so that to reach the nectar, insects

are required to insert their tongues between the filaments. Each filament has on each side of its base a fimbriate appendage which tends to close the interval. Then the ovary is densely clothed with erect bristle-like hairs which also aid in concealing the nectar. The disk surrounding the base of the ovary shows five nectar secreting processes alternating with the filaments.

The flower is homogamous. The style with its receptive stigma rises among the dehiscent anthers, being generally overtopped by them, so that self-pollination may readily occur with or without insect aid.

Probably on account of strong competition with its allies and other plants the flower seems to have gone through a stage in which it was neglected by insects and was compelled to rely upon self-pollination. At present I find it abundantly visited, to an extent that would seem to justify the return of dichogamic characters.

But the damp shady situations in which the plant grows, no doubt, render the visits of insects quite uncertain, so that the power of spontaneous self-pollination becomes a most important condition of selection. The flower is adapted to small bees, especially *Halictus*. It blooms from April 21st to June 21st. May 8th, 12th and 21st the following visitors were observed:

Hymenoptera—*Apidae:* (1) Ceratina tejonensis Cr. ♂, ab.; (2) C. dupla Say ♂♀, ab.; (3) Osmia albiventris Cr. ♂; (4) O. atriventris Cr. ♂♀; (5) Nomada maculata Cr. ♀; *Andrenidae* (6) Andrena violae Rob. ♀; (7) A. ziziae Rob. ♂; (8) Augochlora pura Say ♀, ab.; (9) Halictus 4-maculatus Rob. ♀, ab.; (10) H. pectoralis Sm. ♀; (11) H. fasciatus Nyl. ♀, ab.; (12) H. obscurus Rob. ♀, ab.; (13) H. zephyrus Sm. ♀; (14) H. tegularis Rob. ♀; (15) H. stultus Cr. ♀—all s.

Diptera—*Bombylidae:* (16) Bombylius pulchellus Lw., s.; (17) B. fratellus Wd., s.; *Syrphidae:* (18) Pipiza femoralis Lw., f. p.; (19) Mesograpta marginata Say, f. p.; (20) M. geminata Say, f. p.; (21) Rhingia nasica Say, s.

COMANDRA UMBELLATA Nutt.—The flower is remarkable for being specially adapted to flies. The calyx is white and expands about 5^{mm}. It is generally 5-, sometimes 3- or 4- parted. The tube is 2 or 3^{mm} long, lined within by a green disk which above forms lobes alternating with the stamens and calyx lobes. This disk, especially at its exposed lobes, secretes

nectar which is very attractive to flesh-flies. Visitors have abundant pollen massed about the bases of their proboscides.

The flowers are homogamous. The stigma somewhat surpasses the anthers and is separated from them. I do not think spontaneous self-pollination occurs, unless it be in bad weather.

The plants are common, often in large patches, grow from 1 to 2^{dm} high and expose an umbel-like cluster of flowers. The flowers bloom from April 27th to June 6th. The following list of visitors was observed on May 12th, 16th, 17th, and 19th:

Diptera—*Syrphidae:* (1) Sphaerophoria cylindrica Say, ab.; (2) Volucella vesiculosa F.; (3) Eristalis dimidiatus Wd.; (4) Helophilus latifrons Lw.; (5) Tropidia mamillata Lw.; (6) Syritta pipiens L.; *Tachinidae:* (7) sp.; (8) Trichophora echinomoides Twns.; (9) Gonia frontosa Say; *Sarcophagidae:* (10) Cynomyia sp., very ab.; (11–13) Sarcophaga spp., very ab.; *Muscidae:* (14) Calliphora erythrocephala Mg., freq.; (15) C. vomitoria L.; (6) Lucilia sp., very ab.; (17) L. caesar L., ab.; (18) L. latifrons Schin., freq.; (19) L. sericata Mg., two; (20) L. cornicina F.; (21) L. sylvarum Mg., very ab.; (22) Graphomyia sp.; (23) Myospila meditabunda F.; *Anthomyidae:* (24) Limnophora sp., ab.; (25) Chortophila sp.; (26) Coenosia sp.; *Sciomyzidae:* (27) Tetanocera sp.—all sucking.

Hymenoptera—*Apidae:* (28) Apis mellifica L. ☿; (29) Synhalonia speciosa Cr. ♂; (30) Osmia albiventris Cr. ♀; (31) Nomada superba Cr. ♂; *Andrenidae:* (32) Andrena sayi Rob. ♀; (33) A. flavo-clypeata Sm. ♀: (34) A. mariae Rob. ♀; (35) Halictus lerouxii Lep. ♀; (36) H. confusus Sm. ♀; (37) H. albipennis Rob. ♀; (38) H. tegularis Rob. ♀; (39) Sphecodes arvensis Pttn. ♀—all sucking, rare.

Coleoptera—*Coccinellidae:* (40) Megilla maculata DeG., one; *Lampyridae:* (41) Telephorus bilineatus Say, one—both sucking.

SPIRANTHES GRACILIS Bigelow.[1]—The flowers are white and measure 4 or 5^{mm} long. The parts of the perianth, with the exception of the divergent lower sepals, are disposed so as to limit access to the nectar. The upper sepal is connivent with the two upper petals, forming the upper wall of the tube. At their free ends these parts form a three-toothed upper lip. The lower wall is formed by the labellum, whose

[1]See Darwin: Fertilization of Orchids; Gray: Am. Journn. Sci., XXXIV.

tip forms a lower lip. This is too small to form a landing-place for insects, but makes the flower a little more conspicuous. A proboscis about 4^{mm} long can drain the nectar with ease.

In Gray's Manual the time of blooming is stated to be from July to October, while in Chapman's Flora of the Southern States it is said to be in April and May. In Illinois I have found the plant in bloom in September. At Orlando, Florida, I noted it in bloom from February 18th to March 16th, and at Inverness, Citrus county, from March 15th to 23d. In Illinois I have seen the flowers visited by *Bombus americanorum* F. ♂ and *Calliopsis andreniformis* Sm. ♀. At Orlando, Florida, I saw them visited by a bee which I failed to capture, but which I supposed was *Anthidium notatum* Latr., and by *Megachile brevis* Say ♂.

The last mentioned insect has two boat-shaped discs with attached pollinia fastened to the maxillary laminæ, and I think this is the particular part of a bee to which the flower is adapted to fasten its pollinia. At Torquay, Darwin saw *S. autumnalis* visited by two species of bumble-bees. In one specimen which he examined he states that the pollinia were attached to the superior (maxillary) laminæ. The maxillary laminæ are on the upper side when the proboscis is inserted into a flower, and are the parts which would be expected to touch the disk first. But the most important consideration is that when the bee's proboscis is folded up under the head, the maxillary laminæ fall into such a position that the pollinia retain their hold without danger of being disturbed.

ORCHIS SPECTABILIS L.[2]—In my neighborhood there are many places favorable for the protection of this Orchis, and it is of rather frequent occurrence. It is found on north hill-sides in rather shady places. The scapes grow from 1 to 2^{dm} high and bear several flowers. The labellum with its spur is white. It is nearly pendant and measures from 10 to 15^{mm} long by 8 to 10^{mm} wide. The other parts of the parianth are united into a purplish helm which effectually shelters the column and the mouth of the spur. The spur is from 12 to 15^{mm} long, is somewhat enlarged near the tip, and the nectar rises 2 to 3^{mm}.

The flower is specially adapted to *Bombus* females. At the

[2] See Guignard: 16th ann rep. Ent. Soc., Ontario; Mignault: Bemerkungen über die Befruchtung der Pflanzen.

time when it blossoms (May) only the females of *Bombus* are flying. The disks are applied to the bee's clypeus, which in the female is bare. The clypeus of the male is so hairy that the disks could hardly be properly fastened to them. Long-tongued species of *Anthophora* and *Synhalonia* are flying while the flowers bloom and can reach the nectar, but I do not believe the flowers are adapted to them, because the males, which fly at the same time, have hairy faces, and they would be as apt to visit the flowers. When the pollinia are withdrawn by a bee they stand in a nearly horizontal position, since the bee's clypeus has its face directed nearly vertically, so that in moving downwards to a position in which they will strike the stigma they must be assisted by their own weight.

On May 13th I found a patch of five plants, which bore twenty flowers. With the exception of three flowers, the pollinia were removed from all, and most of the stigmas had received pollen. I saw the flowers visited by the females of *Bombus separatus* Cr. and *B. americanorum* F. The proboscis of the former can drain the short-spurred flowers and obtain some of the nectar which rises in the long spurs. *Bombus americanorum* can easily exhaust the longest spurs. A specimen of this bee which I captured at the flowers has a pair of pollinia on the clypeus.

HABENARIA LEUCOPHÆA Gray.—The plant is rare. It grows on prairies. The stem rises from 4 to 8^{dm} and bears a raceme of greenish white flowers. The flower measures about 20^{mm} long by 15^{mm} wide.

The upper sepal and two upper petals form a galea which shelters the anther. The labellum is three parted, each division being fimbriate. The disks are set one on each side of the entrance to the spur and are separated about 2^{mm}, so that when the hawk-moth throws its proboscis to one side or the other, it is apt to remove one of the pollinia, but is not likely to extract both of them. The spur is very slender and measures from 35 to 40^{mm} in length, indicating that the flower is adapted to Sphingidae. The nectar does not seem to be enclosed between the walls of the spur but appears to occupy the cavity. The height to which it rises can be seen from the outside. Sometimes it fills the spur for 10^{mm} above the tip.

I have found the plant in bloom from June 12th to July 12th. July 2nd I captured at the flowers a specimen of *Chaero-*

campa tersa L. with three disks on its proboscis, about 4^{mm} from the base. At Champaign, Ill., Mr. M. B. Waite showed me a specimen of *Philampelus achemon* Dru., which he had taken on the flowers. It had pollinia about 5^{mm} from the base of the proboscis.

Carlinville, Illinois.

[From Botanical Gazette, Vol. XVIII.]

Flowers and insects. XI.

CHARLES ROBERTSON.

Stellaria media Sm.[1]—"Nat. from Eu."—The plant was observed in bloom from March 14th to Oct. 25th. It is not abundantly visited except in early spring, when the flowers form quite conspicuous patches. At this time frequent cross-pollination is inevitable. On seven days, March 25th to April 29th, and Oct. 15th, I observed the following visitors, all sucking:—

Hymenoptera—*Apidæ:* (1) Apis mellifica L. ☿; (2) Ceratina dupla Say ♂; (3) Osmia lignaria Say ♂; (4) Nomada bisignata Say ♂; (5) N. luteola Lep. ♂; *Andrenidæ:* (6) Panurgus? andrenoides Cr. ♂; (7) Andrena sayi Rob. ♂; (8) A. illinoensis Rob. ♀; (9) A. flavo-clypeata Sm. ♂; (10) A. cressonii Rob. ♂♀; (11) A. forbesii Rob. ♀; (12) Augochlora pura Say ♀, ab.; (13) Halictus lerouxii Lep. ♀; (14) H. ligatus Say ♀; (15) H. fasciatus Nyl. ♀; (16) H. pilosus Sm. ♀; (17) H. gracilis Rob. ♀; (18) H. confusus Sm. ♂♀; (19) H. stultus Cr. ♀; (20) Colletes inaequalis Say ♂; *Chalcididæ:* (21) Smicra torvina Cr.; *Ichneumonidæ:* (22) Pimpla novita Cr. (determined by Ashmead); *Tenthredinidæ:* (23) Dolerus arvensis Say.

Diptera—*Mycetophilidæ:* (24) Sciara sp.; *Syrphidæ:* (25) Chilosia capillata Lw.; (26) Melanostoma obscurum Say; (27) Platychirus quadratus Say; (28) Syrphus ribesii L.; (29) S. americanus Wd.; (30) Mesograpta marginata Say; (31) Eristalis tenax L.; (32) E. aeneus F.; (33) E. dimidiatus Wd.; (34) Brachypalpus frontosus Lw.; (35) Syritta pipiens L.; *Tachinidæ:* (36) Gonia frontosa Say, ab.; (37) G. exul Will.; *Sarcophagidæ:* (38) Cynomyia sp.; *Muscidæ:* (39)

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[1] See Axell: Om anordningarna för de Fanerogama Växternas Befruktning; Lubbock: British Wild Flowers in Relation to Insects; Müller: Fertilization of Flowers, and Weit. Beobachtungen; Henslow: Self-fertilization of Plants; Anna Bateson: The Effects of Cross-fertilization on Inconspicuous Flowers, Annals of Botany, I; Meehan: Contributions to the Life Histories of Plants, III, Proc. Acad. Sci. Phila., 1888; Battandier: Sur quelques cas d'heteromorphisme, Bull. Soc. bot. France, XXX; Ludwig: Botan. Ver. d. Provinz Brandenburg, XXVI; MacLeod: Untersuchungen über die Befruchtung einiger phanerogamen Pflanzen d. Belgischen Flora, Bot. Centralblatt, XXIII; Schulz: Beiträge zur Kenntniss d. Bestäubungseinrichtungen u. Geschlechtsvertheilung bei den Pflanzen.

Pollenia rudis F.; (40) *Musca domestica* L.; (41, 42) Lucilia spp.; (43) L. cornicina F.; (44) Myospila meditabunda F.; *Anthomyidæ:* (45) Chortophila sp.; *Cordyluridæ:* (46) Scatophaga squalida Mg.

Lepidoptera—*Nymphalidæ:* (47) Pyrameis huntera F.; *Lycaenidæ:* (48) Lycaena pseudargiolus B.-L.

Hemiptera—*Lygaeidæ:* (49) Lygaeus turcicus F.

	Bees.	Other Hymenoptera	Diptera	Other insects.	Total.
In Low Germany—Müller....	15	1	8	1	25
In Illinois.................	20	3	23	3	49

MALVA ROTUNDIFOLIA L.[2]—"Nat. from Eu."—In the Fertilization of Flowers Müller says that the flowers of this species attract few insects, and he gives a list of visitors which compares very unfavorably with the list taken on flowers of *M. sylvestris*. In Illinois the plant seems to have little difficulty in acquiring a useful set of visitors. The subjoined list compares favorably with Müller's list of visitors of *M. sylvestris*. The plant blooms from April to November. On eleven days, between May 14th and October 9th, the following insects were observed visiting the flowers:—

Hymenoptera—*Apidae:* (1) Apis mellifica L. ☿, s., freq.; (2) Bombus pennsylvanicus DeG. ♀, s.; (3) Melissodes bimaculata Lep. ♂, s.; (4) Ceratina dupla Say ♀, s. and c. p.; (5) Nomada incerta Cr. ♀, s.; (6) Calliopsis andreniformis Sm. ♂♀, s. and c. p., ab.; *Andrenidae:* (7) Agapostemon bicolor Rob. ♂♀, s. and c. p.; (8) A. radiatus Say ♂, s., freq.; (9) Augochlora pura Say ♂♀, s.; (10) Halictus pectoralis Sm. ♂♀, s.; (11) H. similis Sm ♀, s. and c. p.; (12) H. coriaceus Sm. ♀, s.; (13) H. ligatus Say ♂♀, s.; (14) H. fasciatus Nyl. ♀, c. p., freq.; (15) H. pilosus Sm. ♀, s.; (16) H. zephyrus Sm. ♂, s., (17) H. confusus Sm. ♂♀, s., ab.; (18) H. illinoensis Rob. ♀, s.; (19) H. stultus Cr. ♂, s.; (20) Prosopis affinis Sm. ♀, f. p.

[2]See Sprengel: Das entdeckte Geheimniss; Lubbock: British Wild Flowers in relation to Insects; Henslow: On the Self-fertilization of Plants—Trans. Linn. Soc. II. 1; On the fertilization of flowers by bees and other insects—Journ. Roy. Hort. Soc. London, VI; Müller: Fertilization of Flowers, and Weit. Beobachtungen; MacLeod: Pyreneenbloemen en hare bevruchting door insecten; Keller: Proc. Acad. Nat. Sci. Phila., 1892, 452.

Diptera—*Syrphidae:* (21) Mesograpta marginata Say, s. and f. p.; *Muscidae:* (22) Lucilia cornicina F., s.; *Anthomyidae:* (23) Chortophila sp., s., freq.

Lepidoptera—*Rhopalocera:* (24) Pieris rapæ L., s.

Coleoptera—*Malachidae:* (25) Collops 4-maculatus F., f.p.

	Halictus.	Other bees.	Other insects.	Total.
In the Pyrenees—MacLeod	–	1	–	1
In Low Germany—Müller	2	3	1	6
In Illinois	13	7	5	25

SIDA SPINOSA L.—"Nat. from the tropics."—The stigmas receive pollen from the dehiscent anthers, but may be effectually dusted with pollen from other flowers in case of early insect visits. Later the styles bend and turn the stigmas in among the anthers, so that thorough self-pollination is insured. The plant has small yellow flowers. It was noted in bloom from July 25th to October 3d, and the following visitors were observed:—

Hymenoptera—*Apidæ:* (1) Bombus americanorum F. ♂☿, s.; (2) Ceratina dupla Say ♀, s. and c. p.; *Andrenidæ:* (3) Augochlora pura Say ♂, s.

Lepidoptera—*Papilionidæ:* (4) Pieris protodice B.-L.; (5) P. rapæ L.; (6) Colias philodice Gdt.; (7) Terias lisa B.-L.; *Hesperidæ:* (8) Pyrgus tassellata Scud.

ABUTILON AVICENNÆ Gærtn.—"Adv. from India."—The flowers are yellow and occupy very inconspicuous positions under the large leaves. They are spontaneously self-pollinated in absence of insects, but may be cross-pollinated in their presence. For a long time I thought that nectar was wanting and that visitors never occurred, but in three days, August 21st to September 19th, I captured the following insects on the flowers:—

Hymenoptera—*Apidæ:* (1) Apis mellifica L. ☿, s.; (2) Bombus separatus Cr. ☿, s.; (3) B. americanorum F. ♂☿, s.; (4) Melissodes bimaculata Lep. ♀, s. and c. p.; *Andrenidæ:* (5) Halictus confusus Sm. ♀, c. p.; (6) H. fasciatus Nyl. ♀, s.; (7) H. coriaceus Sm. ♀, s.

Diptera—*Syrphidæ:* (8) Mesograpta marginata Say, f. p.; *Anthomyidæ:* (9) Chortophila sp., s.

Lepidoptera—*Papilionidae:* (10) Pieris rapæ L.; *Hesperidæ:* (11) Pholisora catullus F.

HIBISCUS LASIOCARPUS Cav.—With the exception of a single specimen of *Hibiscus militaris*, this is the only indigenous species of Malvaceæ which I have found in my neighborhood, and, as might have been expected, is the only one in which spontaneous self-pollination is impossible. It grows in swamps. The stalks, several of which form a cluster, rise from one to two metres, each stalk exposing two or three large flowers at a time.

The flowers are white or rose-tinted, with a crimson centre. They measure from eight to ten centimetres in length, and expand from nine to eleven centimetres, or more. The lower petals are directed horizontally; the upper are bent strongly upward like a vexillum, so as to be nearly perpendicular to the lower. The column lies near the lower petals and for about three centimetres from its base is provided with free filaments, which project upwards and sideways. On account of the flower being in an incipient stage of irregularity, the column still retains some useless filaments on the lower side, whose anthers seldom touch the bees. The five large capitate stigmas, which form a circle from nine to thirteen millimetres across, are advanced one or two centimetres before the nearest anthers, so that there is no chance of spontaneous self-pollination.

When visiting the flower, bees land upon the base of the column. The latter is bent upwards in such a position that the bees touch the stigmas before they alight. After sucking, the bees crawl out over the filaments and upon the lower petals and leave the flower without again touching the stigmas.

After alighting upon the column, *Emphor bombiformis*, which is the characteristic visitor, turns to the right or left and thrusts its proboscis into one nectary after another until it reaches the narrow interval between the column and the lower petals. Then it often turns back and inserts its proboscis into the nectary on the other side. Commonly, however, it fails to squeeze under the column to visit the nectary which lies there, and it often neglects to turn back for the nectary on the other side, and so leaves the flower without extracting the sweets from all the nectaries. Seventy-six individuals which I watched at this work missed eighty-one

nectaries in seventy-six flowers. On the other hand, *Bombus americanorum*, which is larger, more time-saving and less familiar with the flower, more frequently neglects to visit the nectary under the column and seldom turns back, so that it misses the lower nectaries even more frequently. I saw fifty-six individuals of this species miss eighty-five nectaries in fifty-six flowers. Both species also often miss the lower nectaries because, after inserting their proboscides into the upper ones and finding them empty, they arrive at the erroneous conclusion that the lower ones are in the same condition.

In their economy, the flowers of this plant and the bee first mentioned, *Emphor bombiformis*, stand in a very close relation. With the exception of single individuals taken on flowers of *Cephalanthus occidentalis* and *Ipomœa pandurata*, I have never taken this bee on any other flower. On the *Hibiscus* I have never failed to find it in favorable weather, and I have found the males in the closed flowers in bad weather. No specimens have been observed by me except during the blooming time of the plant, from July 25th to Sept. 16th. The female is provided with a large loose scopa which seems to be specially fitted to retain the large pollen grains, and this is the only flower on which I have seen it collecting pollen. Accordingly, I think the bee depends exclusively upon Hibiscus pollen for food for its larvae. I have seen the female making excavations for her nest within a few yards of the plants.

The only other insect at all frequent on the flower is *Bombus americanorum* F. ♂♀☿. I have never found this bee half as abundant, and commonly absent altogether, while the *Emphor* was abundant. This bumble-bee never collects the pollen. In addition to these insects I have seen the flowers visited for honey only by *Melissodes bimaculata* Lep. ♂♀ and by single individuals of *Bombus separatus* Cr. ♀, *Entechnia taurea* Say ♂, *Megachile brevis* Say ♂, *Euphoria sepulchralis* F. and *Trochilus colubris* L.

HIBISCUS TRIONUM L.[3]—"Adv. from Eur."—The five capitate stigmas stand close together, and pollen only touches the edges next to the dehiscent anthers. Most of the stigmas are thus free from pollen and can be effectually cross-pollinated in case of insect visits. After the flowers close, the styles bend outward and downward forcing the stigmas

[3] See Sprengel: Das entdeckte Geheimniss.

among the anthers so as to cover them with pollen. Thorough self-pollination is, therefore, only effected by a special movement of the stigmas, and only occurs after the flower has been exposed to insects. I have seen it visited only by a single individual of *Pieris rapæ* L.

GERANIUM CAROLINIANUM L.—The plant is common, blooming from May 23d to July 13th. The stem rises from 2 to 4^{dm}, is diffusely branched and bears numerous pale rose-colored flowers, which are not crowded so as to form an attractive combination.

The corolla is small, measuring about 7^{mm} across. In forms observed by me there are ten perfect stamens. The flowers are imperfectly proterandrous. The anthers of the inner circle are so closely approximated to the stigmas, that in absence of insects, spontaneous self-pollination may readily occur.

The flowers are adapted to small bees. June 10th I observed the following visitors:

Hymenoptera—*Apidæ:* (1) Alcidamea producta Cr. ♂♀, s., freq.; (2) Osmia conjuncta Cr. (=4-dentata Cr. ♂) ♀, s.; (3) Calliopsis parvus Rob. ♀, s. and c. p.; *Andrenidæ:* (4) Agapostemon radiatus Say ♀, s.; (5) Augochlora pura Say ♀, s. and c. p., freq.; (6) Halictus pectoralis Sm. ♀, s. and c. p., freq.; (7) H. tegularis Rob. ♀, s. and c. p.; (8) H. stultus Cr. ♀, c. p.; (9) Prosopis affinis Sm. ♀, s., freq.; *Eumenidæ:* (10) Odynerus sp., s., freq.

Diptera—*Syrphidæ:* (11) Mesograpta marginata Say, s., freq.; *Tachinidæ:* (12) Hyalomyia purpurascens Twns. s., one.

OXALIS VIOLACEA L.[4]—The scapes rise one decimetre, or more, high and expose an umbel of rose-purple flowers. The five petals expand 20^{mm}. At base they are approximated into a tube about 5^{mm} long, very wide in the throat, but obstructed by the ten stamens and five styles. The tube within is whitish, with greenish streaks proceeding from a greenish base. The calyx is about 4^{mm} long and is erect, aiding in giving firmness to the tube. In the long-styled form, spontaneous self-pollination is impossible, but in the short-styled form it may occur by the pollen falling upon the stigmas.

The plant is common and blooms from April 6th to June 10th. It is very abundantly visited by bees, mostly species

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[4]See Trelease: The Heterogony of Oxalis violacea, Am. Nat. XVI; North American Geraniaceæ, Mem. Bost. Soc. Nat. Hist. IV; Trans. St. L. Acad. Science, V; Bot. Gaz. XII; Christy: Journ. of Bot. XXIII.

of small size. On eight days, between May 1st and 17th, I observed the following visitors:—

Hymenoptera—*Apidæ:* (1) Apis mellifica L. ☿, s.; (2) Bombus americanorum F. ♀, s.; (3) B. pennsylvanicus DeG. ♀, s.; (4) Synhalonia speciosa Cr. (=Melissodes dilecta Cr. ♂) ♂ ♀, s., freq.; (5) Ceratina tejonensis Cr. ♂, s., (6) C. dupla Say ♂ ♀, s., freq.; (7) Osmia cognata Cr. ♂, s.; (8) O. albiventris Cr. ♀, s. freq.; (9) Nomada superba Cr. ♀, s.; (10) N. annulata Sm. (=articulata Cr. nec Sm.) ♂, s.; (11) N. sayi Rob. ♂ ♀, s., freq.; (12) N. cressonii Rob. ♂; *Andrenidæ:* (13) Andrena violæ Rob. ♀, s.; (14) A. ziziæ Rob. ♂♀, s.; (15) Agapostemon bicolor Rob. ♀, s.; (16) A. radiatus Say ♀, s.; (17) Augochlora pura Say ♀, s., ab.; (18) Halictus pectoralis Sm. ♀, s.; (19) H. forbesii Rob. ♀, s.; (20) H. lerouxii Lep. ♀, s. and c. p., ab.; (21) H. ligatus Say ♀, s. and c. p.; (22) H. fasciatus Nyl. ♀, s. and c. p., ab.; (23) H. pilosus Sm. ♀, s. and c. p., ab.; (24) H. confusus Sm. ♀, s.; (25) H. albipennis Rob. ♀, s.

Lepidoptera—*Rhopalocera:* (26) Phyciodes tharos Dru.; (27) Colias philodice Gdt., (28) Nisoniades brizo B.-L.

Melilotus alba Lam.—"Adv. from Eur."—The plant is common along side-walks. The stems rise from 6 to 12^{dm}, or more, in height and bear a profusion of spikes crowded with white blossoms. The flower measures about 4^{mm} in length to the tip of the keel. The calyx tube measures about 1^{mm} in depth, so that the nectar is easily accessible to short-tongued insects.. The flower agrees in all essentials, except color, with that of *M. officinalis*, as described and figured by Müller in Fertilization of Flowers, 180. Müller saw *M. alba* visited by *Apis mellifica* L. ☿, *Macropis labiata* Pz. and *Empis livida* L.

The following were observed on June 23d and 25th:—

Hymenoptera—*Apidæ:* (1) Apis mellifica L. ☿, s., ab.; (2) Bombus separatus Cr. ☿, s.; (3) Ceratina dupla Say ♀, s. and c. p.; (4) Megachile brevis Say ♀, s. and c. p.; (5) Alcidamea producta Cr. ♀, s. and c. p.; (6) Coelioxys 8-dentata Say ♂♀, freq.; (7) Epeolus fumipennis Say ♂, s., freq.; (8) Nomada incerta Cr. ♀, s.; (9) Calliopsis andreniformis Sm. ♂♀, s. and c. p.; *Andrenidæ:* (10) Macropis steironematis Rob. ♂♀, s. freq.; (11) Augochlora similis Rob. ♂, s.; (12) Halictus arcuatus Rob. ♀, s. and c. p.; (13) H. parallelus Say ♀, s.; (14) H. lerouxii Lep. ♂♀, s. and c. p.; (15) H. ligatus Say ♀, s. and c. p.; (16) H. fasciatus Nyl. ♀, s.;

(17) H. albipennis Rob. ♀, s. and c. p.; (18) H. confusus Sm. ♂♀, s. and c. p., ab.; (19) H. pruinosus Rob. ♂, s.; (20) Sphecodes arvensis Pttn. ♂, s.; (21) Colletes eulophi Rob. ♂♀, s.; (22) C. willistonii Rob. ♀, s.; *Vespidæ:* (23) Polistes pallipes Lep., s.; *Eumenidæ:* (24–26) Odynerus spp.; (27) Odynerus fulvipes Sauss.; (28) O. arvensis Sauss.; (29) O. foraminatus Sauss., freq.; (30) O. megæra Lep.; *Crabronidæ:* (31) Crabro interruptus Lep., freq.; (32) Oxybelus emarginatus Say; *Philanthidæ:* (33) Cerceris clypeata Dlb.; *Sphecidæ:* (34) Ammophila gryphus Sm.; (35) A. vulgaris Cr.; (36) A. pictipennis Walsh.; (37) A. intercepta Lep.; (38) Isodontia philadelphica Lep.; (39) Sphex ichneumonea L.; (40) S. pennsylvanica L.; (41) Priononyx atrata Lep.; *Pompilidæ:* (42) Pompilus sp.; (43) P. relativus Fox; (44) P. navus Cr.

Diptera—*Empidæ:* (45) Empis sp.; *Conopidæ:* (46) Oncomyia loraria Lw.; (47) Conops brachyrrhynchus Mcq.; *Syrphidæ:* (48) Platychirus quadratus Say; (49) Syrphus americanus Wd.; (50) Allograpta obliqua Say; (51) Sphaerophoria cylindrica Say; (52) Syritta pipiens L.; *Tachinidæ:*[6] (53) Cistogaster occidua Wlk.; (54) Ocyptera euchenor Wlk. freq.; (55) Jurinia apicifera Wlk.; (56) J. smaragdina Mcq.; (57) Cuphocera ruficauda v. d. W.; (58) Micropalpus fulgens Mg., ab.; (59) Phorocera edwardsii Will.; (60) Acroglossa hesperidarum Will., ab.; (61) Trichophora echinomoides Twns., ab.; (62) Oliviera americana Twns.; (63) Pseudomyothyria nigricornis Twns.; *Sarcophagidæ:* (64–65) Sarcophaga spp.; *Muscidæ:* (66) Cyrtoneura sp.; (67) Lucilia caesar L.; (68) L. cornicina F. —all s.

Lepidoptera—*Rhopalocera:* (69) Chrysophanus thoe B.-L.; (70) Thecla humuli Harr.; *Sesiidæ:* (71) Sesia sexfasciata Hy. Edw.

Coleoptera—*Scarabaeidæ:* (72) Trichius piger F., s.; *Cerambycidae:* (73) Typocerus sinuatus Newm., s.; *Mordellidæ:* (74) Mordella marginata Melsh., s.; *Curculionidæ:* (75) Centrinus sp.; (76) C. picumnus Hbst.; (77) C. scutellum-album Say, freq.

Hemiptera—*Lygaeidæ:* (78) Lygaeus turcicus F., s.; *Pentatomidæ:* (79) Podisus spinosus Dal., s., one.

Carlinville, Ills.

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[6]The Tachinidæ mentioned in this paper were determined by Mr. C. H. Tyler Townsend.

Mr J. H. Burkill
with compliments of
author

[From the Botanical Gazette, Vol. XIX.]

Flowers and insects. XII.

CHARLES ROBERTSON.

Clematis Virginiana L.—The flower, with its horizontally expanded sepals, measures about 2^{cm} across. The flower clusters form large, white masses upon the shrubs upon which the plants climb. The flowers are dioecious. The white color and the easily accessible nectar attract numerous, mostly small, short-tongued insects. The visitors, however, are principally flies, three-fifths of the species being of this kind.

An interesting comparison may be made between this plant and *Isopyrum biternatum*, an account of which is given in the Gazette, **17**: 173–5. 1892. The flowers of both species are white, though the Clematis is more conspicuous, and the extent of nectar concealment is almost identical. Nevertheless, the species show a marked difference in the kinds of insects visiting them, as the following table will show:

	Bees.	Other Hymenop.	Syrphidæ.	Tachinidæ.	Muscidæ.	Other Diptera.	Other insects.	Total.
Isopyrum biternatum	31	0	10	1	1	2	5	50
Clematis Virginiana	9	10	6	10	7	11	2	55

The difference is mainly a result of the time of blooming. Isopyrum, according to my observations, blooms from March 24th to May 12th, and Clematis Virginiana from July 11th to Aug. 16th. During the blooming time of the former, bees are almost as abundant as during the blooming time of the latter. Of the lower aculeate Hymenoptera I have never seen in my neighborhood more than six species during the period of Isopyrum, though they become more abundant about the time the plant goes out of bloom; but they reach their maximum during the period of Clematis Virginiana, within which time I have noted 115 species flying simultaneously.

Then Isopyrum is exposed to a tachinid fauna of only six species also, while the Clematis is exposed to thirty or more

species. The *Muscidæ* are also more abundant while Clematis Virginiana is in bloom. It seems that bees and *Syrphidæ*, therefore, are less abundant on the Clematis on account of the competition of the lower Hymenoptera and the other Diptera.

As far as I have observed in my neighborhood, this is the latest blooming of the Ranunculaceæ. By late blooming it gains the signal advantage of avoiding competition with such allies as Ranunculus, Isopyrum, Anemonella, etc., and it finds the general anthophilous insect fauna at its maximum. Its period overlaps with the periods of *C. Pitcheri* and *Anemone Virginiana*. *C. Pitcheri*, its congener, is hardly a competitor, since, as observed below, it is adapted to bumble-bees. The Anemone, being a pollen flower, also avoids competition to some extent by attracting a different set of insects.

The following insects were taken from the staminate flowers on July 27th, 28th, 30th and August 3d:

HYMENOPTERA.—*Apidae*: (1) Apis mellifica L. ☿, s.; (2) Bombus virginicus Oliv. ☿, s. and c. p.; *Andrenidae:* (3) Halictus zephyrus Sm. ♂♀, s. and c. p.; (4) H. confusus Sm. ♂♀, s. and c. p.; (5) H. stultus Cr. ♂♀, s. and c. p., the most abundant visitor; (6) H. cressonii Rob. ♂; (7) Sphecodes arvensis Pttn. ♂, s.; (8) S. confertus Say ♀, s.; (9) Prosopis affinis Sm. ♂♀, s.; *Eumenidae:* (10) Odynerus tigris Sauss., s.; (11) O. foraminatus Sauss., s.; *Crabronidae:* (12) Crabro minimus Pk., s.; (13) C. interruptus Lep., s.; (14) Oxybelus 4-notatus Say, s.; *Nyssonidae:* (15) Nysson plagiatus Cr., s.; *Sphecidae:* (16) Pelopoeus cemenrarius Dru., s.; (17) Isodontia philadelphica Lep., s.; (18) Sphex ichneumonea L., s.; *Scoliidae:* (19) Scolia bicincta F., s.

DIPTERA.—*Conopidae:* (20) Oncomyia loraria Lw., s.; *Syrphidae:* (21) Platychirus quadratus Say; (22) Allograpta obliqua Say; (23) Mesograpta marginata Say; (24) Sphaerophoria cylindrica Say; (25) Eristalis transversus Wd.; (26) Syritta pipiens L.; *Tachinidae:* (27) Exorista sp.; (28) Loewia globosa Twns.; (29) Hyalomyia purpurascens Twns.; (30) Jurinia apicifera Wlk.; (31) J. smaragdina Mcq.; (32) Micropalpus fulgens Mg.; (33) Frontina flavicauda Riley; (34) Siphona illinoensis Twns.; (35) Miltogramma argentifrons Twns.; (36) Sarcomacronychia aurifrons Twns.; *Sarcophagidae:* (37) Sarcophaga sp.; *Muscidae:* (38) Calliphora erythrocephala Mg.; (39) Graphomyia sp.; (40) Lucilia sp.; (41) L.

latifrons Schin.; (42) L. cornicina F.; (43) Compsomyia macellaria F.; (44) Musca domestica L.; *Anthomyidae:* (45) Homalomyia canicularis L.; (46) Anthomyia albicincta Fll.; (47–48) Chortophila spp.; *Sepsidae:* (49) Sepsis sp.; *M. acalyptratae:* (50–53) spp.—all sucking.

LEPIDOPTERA.—*Lycaenidae:* (54) Lycaena pseudargiolus B.-L., s.

HEMIPTERA.—*Capsidae:* (55) Lopidea media Say, s.

CLEMATIS PITCHERI Torr. and Gray.[1]—In this case we have a bumble-bee flower produced by a very simple modification. The sepals, instead of being expanded horizontally so as to admit all sorts of insects to the pollen produced in the anthers, and to the nectar secreted by the filaments, are thick and rigid and have their edges so closely approximated that bees are only admitted at the small opening formed by their separating tips.

The flower is nodding and is purplish exteriorly. It measures about 2^{cm} long and opens to the extent of 5^{mm}. The tips of the sepals are pointed and reflexed, so as to form foot-holds for the visiting bumble-bees. As observed above, nectar is secreted by the filaments. After a bee has inserted its head as far as it will go, it still needs a proboscis from 12 to 15^{mm} long to exhaust the nectar supply.

In newly opened flowers, the stigmas are so far advanced (4^{mm}) before the anthers that cross-pollination very readily occurs by the bees touching them before disturbing the pollen. Later, when the inner anthers dehisce, spontaneous self-pollination may occur by these anthers, which finally equal the stigmas, coming in contact with the latter.

I have seen the flowers visited for nectar by *Bombus vagans* Sm. ♀, and by *Volucella vesiculosa* F.

RANUNCULUS SEPTENTRIONALIS Poir.—The plant is common, growing in scattered patches in low, rich soil. At first the flowers rise 1 or 2^{dm}, the stems finally elongating so as to hold them above the surrounding grass. The spreading stems bear only a few open flowers at a time, which renders them less conspicuous, but increases the probability of cross-pollination between flowers of distinct plants.

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[1]This plant resembles *C. Viorna*, which is described and figured by Foerste in Am. Nat. **19**: 397. 1885.

The bright yellow petals expand horizontally, the flower measuring 2 or 3^{cm} across.

The flower is proterogynous. The styles elongate, holding their receptive stigmas above the anthers, which at first are all closed. The outer stamens lengthen and discharge first, the dehiscence being extrorse.

There is abundant opportunity for cross-pollination before the anthers begin to discharge. Later cross- or self-pollination may occur by insect aid. There is no doubt that self-pollination depends mainly upon the visits of insects. If, however, the stigmas remain untouched until the inner anthers discharge, spontaneous self-pollination may occur by pollen falling upon the stigmas, since the inner filaments finally lengthen so as to hold the dehiscent anthers over the stigmas. The plant was observed in bloom from April 8th to May 24th. On six days, between April 16th and May 7th, the following list of visitors was observed:

HYMENOPTERA.—*Apidæ:* (1) Synhalonia belfragei Cr. ♂, s.; (2) Ceratina tejonensis Cr. ♂, s.; (3) C. dupla Say ♂♀, s. and c. p., ab.; (4) Osmia albiventris Cr. ♂♀, s. and c. p., ab.; (5) O. conjuncta Cr. ♀, c. p.; (6) O. lignaria Say ♀, s. and c. p.; (7) O. cognata Cr. ♂, s.; *Andrenidæ*: (8) Andrena polemonii Rob. ♂♀, s. and c. p., ab.; (9) A. cressonii Rob. ♀, s. and c. p.; (10) A. ziziæ Rob. ♂, s.; (11) Augochlora labrosa Say ♀, s.; (12) A. pura Say ♀, s. and c. p., ab.; (13) Halictus 4-maculatus Rob. ♀, s.; (14) H. pectoralis Sm. ♀, s. and c. p.; (15) H. coriaceus Sm. ♀, s. and c. p.; (16) H. lerouxii Lep. ♀, s. and c. p.; (17) H. ligatus Say ♀, s. and c. p.; (18) H. fasciatus Nyl. ♀, s. and c. p.; (19) H. pilosus Sm. ♀, s. and c. p.; (20) H. obscurus Rob. ♀, s. and c. p.; (21) H. stultus Cr. ♀, s.; (22) H. zephyrus Sm. ♀, s.; (23) Sphecodes dichroa Sm. ♂, s.

DIPTERA.—*Bombylidæ:* (24) Bombylius pulchellus Lw., s., one; (25) B. fratellus Wd., s.; *Syrphidæ:* (26) Pipiza pistica Will., f. p.; (27) P. femoralis Lw., f. p.; (28) Chilosia capillata Lw., s. and f. p., ab.; (29) Melanostoma obscurum Say, s. and f. p.; (30) Syrphus ribesii L., s. and f. p.; (31) S. americanus Wd., s. and f. p.; (32) S. arcuatus Fll., f. p.; (33) Mesograpta geminata Say, f. p.; (34) Sphærophoria cylindrica Say, f. p.; *Tachinidæ:* (35) Siphona illinoensis Twns., s; *Muscidæ:* (36) Cyrtoneura sp.; *Anthomyidæ:* (37) Hydrophoria sp., s.; (38) Homalomyia sp., s; (39–40) Anthomyia spp., s.; (41–42) Chortophila sp., s.

COLEOPTERA.—*Carabidæ:* (43) Lebia viridis Say; *Coccinellidæ:* (44) Megilla maculata DeG., f. p.; *Chrysomelidæ:* (45) Diabrotica vittata F., f. p.; *Œdemeridæ:* (46) Asclera ruficollis Say, f. p.; *Anthicidæ:* (47) Corphyra terminalis Say, f. p.; *Curculionidæ:* (48–49) Centrinus spp., f. p.

LEPIDOPTERA.—*Hesperidæ:* (50) Nisoniades juvenalis F., s.; (51) N. brizo B.-L., s.; (52) Eudamus bathyllus S.-A., s.

RANUNCULUS FASCICULARIS Muhl.—This is the common early buttercup, blooming from March 24th to May 19th. The stems rise about 1^{dm}. Each plant commonly shows only one or two open flowers at a time, so that in this case pollination between distinct plants is apt to occur; but well developed plants often show several flowers, when pollination is more likely to take place between flowers of the same plant.

The flowers are bright yellow, expanding from 15 to 25^{mm}. Newly opened flowers are less widely spread. They show the indehiscent anthers crowded in a compact mass, and the stigmas surpassing them by $1–2^{mm}$. At this time, the stigmas are receptive, and I have often found them thoroughly dusted with pollen which must have come from other flowers. The flowers are therefore proterogynous and are generally cross-pollinated. In older flowers the petals are lengthened and more expanded. The stamens also lengthen and finally overtop the stigmas, the anthers nearly concealing them. At this time, if fertilization has not already taken place, spontaneous self-pollination may readily occur by the stigmas receiving pollen from the anthers which now overtop them, and often touch them, as in the preceding.

On account of its earlier blooming, its more scattered habit, and the more exposed situations in which it grows, R. fascicularis is not so abundantly visited by insects as is the case with R. septentrionalis, though it shows a very similar list.

The following visitors were observed on six days, between April 11 and May 5:

HYMENOPTERA.—*Apidæ:* (1) Apis mellifica L. ☿, s.; (2) Ceratina tejonensis Cr. ♂, s.; (3) C. dupla Say ♂♀, s., freq.; (4) Osmia albiventris Cr. ♂♀, s., freq.; (5) Nomada sayi Rob. ♂, s.; *Andrenidæ:* (6) Andrena violæ Rob. ♂, s.; (7) A. cressonii Rob. ♀, s.; (8) A. flavo-clypeata Sm. ♂, s.; (9) Halictus pectoralis Sm. ♀, s. and c. p.; (10) H. coriaceus Sm. ♀, s.; (11) H. ligatus Say ♀, s. and c. p.; (12) H. fasciatus Nyl. ♀, s. and c. p.; (13) H. pilosus Sm. ♀, s.; (14) H. confusus Sm. ♀, s.,

freq.; (15) H. pruinosus Rob. ♀, s. and c. p.; (16) H. stultus Cr. ♀, s.; (17) Augochlora pura Say ♀, s. and c. p., freq.; (18) Agapostemon radiatus Say ♀, s. and c. p., freq.

DIPTERA.—*Bombylidæ:* (19) Bombylius fratellus Wd., s.; *Syrphidæ:* (20) Chilosia capillata Lw., s.; (21) Melanostoma mellinum L.; (22) Syrphus arcuatus Fll., s.; (23) S. americanus Wd.; (24) Mesograpta marginata Say, s. and f. p., freq.; (25) M. geminata Say, s., freq.; (26) Sphaerophoria cylindrica Say, s. and f. p.; (27) Eristalis transversus Wd., f. p.; (28) Xylota fraudulosa Lw.. s.; *Tachinidæ:* (29) Gonia frontosa Say, s., freq.; *Sarcophagidæ:* (30) Sarcophaga sp., s.; *Muscidæ:* (31) Lucilia cornicina F., s.; *Anthomyidæ:* (32) Chortophila sp., s., freq.

LEPIDOPTERA.—*Papilionidæ:* (33) Colias philodice Godt., s.

COLEOPTERA.—*Œdemeridæ:* (34) Asclera ruficollis Say, f. p.

RANUNCULUS ABORTIVUS L.[2]—Although apparently in need of a chance to pollinate its stigmas with pollen from its own stamens, as in the cases of R. fascicularis and septentrionalis, the flowers of this species do not seem to be able to effectually self-pollinate.

Newly opened flowers have receptive stigmas before the anthers dehisce and are consequently proterogynous. Soon the outer anthers begin to dehisce extrorsely and early become reflexed. At this time the central carpels are above and entirely out of reach of the anthers. Later the stamens lengthen, but then the same carpels are still removed by the elongation of the receptacle. The lower pistils, however, may receive pollen directly from the surrounding anthers, when these have dehisced.

The stems grow from 1–4^{dm} high, and bear numerous small flowers about 5–8^{mm} wide. The petals are minute, and bear nectar pits on their bases, not protected by a scale. Although the flowers are quite inconspicuous, as compared with the two preceding species, under favorable conditions they attract insects in sufficient numbers to insure cross-pollination. But it would take long and patient watching to make out a list equal to the lists of either R. septentrionalis, or fascicularis. On the 5th of May I noted as visitors:

HYMENOPTERA.—*Andrenidae:* (1) Andrena ziziae Rob. ♂, s., freq.; (2) Halictus stultus Cr. ♀, s. and c. p.; (3) Augochlora pura Say ♀, s.

[2]See Meehan: Contributions to the Life-Histories of Plants, VII., Proc. Acad. Nat. Sci. Philad., 1892.

COLEOPTERA.—*Coccinellidae:* (4) Megilla maculata DeG., f. p.; (5) Coccinella 9-notata Hbst., s.

The three species of Ranunculus, an account of which has been given above, are in competition with one another and with other members of the genus, as well as with other members of the order, such as Isopyrum, Anemonella, Myosurus, Hydrastis, etc. In the period from the latter part of April to the middle of May, which is the maximum period of Ranunculaceæ, *Delphinium tricorne* and *Aquilegia Canadensis* are also in bloom, but they can hardly be regarded as competitors, since the former is adapted to bumble-bees and the latter to humming-birds.[3]

HYPERICUM CISTIFOLIUM Lam.—The stems grow from 3–6^{dm} high and are often collected in rather conspicuous patches. The flowers appear in many-flowered cymes, are yellow, and expand about 15^{mm}. Of the numerous stamens the inner dehisce first, rising to the centre. The flowers are homogamous, with a chance of self-pollination. The homogamy, however, does not exist as a provision for self-pollination, though under certain conditions, it may be of advantage for this purpose; but is correlated with the fact that the flowers are devoid of nectar, and are visited exclusively for pollen.

Homogamy is a common characteristic of pollen-flowers, as well as of many highly organized flowers which secrete nectar and yield abundant pollen. The fact is that dichogamy acts disadvantageously in all cases in which a numerous set of visitors come exclusively for pollen, for these visitors neglect the flowers which are in the pistillate stage.

Hypericum cistifolium depends almost exclusively on bumble-bee females and workers, which visit it to collect pollen. On seven different days I noted them thus engaged. The species were: (1) *Bombus americanorum* F. ♀☿, ab.; (2) *B. pennsylvanicus* DeG. ☿; (3) *B. separatus* Cr. ♀☿, ab. On one occasion I saw the pollen collected by *Agapostemon bicolor* Rob. ♀. The flowers bloom from June 18 to July 22.

XANTHOXYLUM AMERICANUM Mill.—The northern prickly ash blossoms in early spring, and its blooming time is of short duration, Apr. 12th to 28th. The shrubs grow in small clumps and rise from 1–2^{m}. The greenish flowers are in small umbel-like clusters and are no more conspicuous than the young leaves

[3]See Todd: Am. Nat. **14**: 668, and Trelease: ibid., 731.

with which they appear; but insect visits are secured by abundant nectar secreted by the large gynobase. The corolla forms a loose tube about 2^{mm} long, beyond the tip of which the entire length of the conniving styles is exserted. The ovaries and the gynobase each occupy about half of this tube. The elevation of the ovaries gives them the novel function of obstructing the tube and to some extent concealing the nectar, and the most convenient passages to the nectar are the intervals between them. In the staminate flowers the gynobase is developed into a more widely expanded disc, with lobes extending between the filaments. In this form the nectar is concealed by the filaments and by the rudimentary ovaries. Access to it is most convenient between the filaments. Cross-fertilization between distinct plants is secured by dioecism. In spite of the inconspicuousness of the flowers abundant insect visits are insured.

This is a good illustration of the value of nectar as an entomophilous character of flowers. The secretion of nectar is, as a rule, all that is necessary to induce insect visits to flowers in natural situations and under fairly favorable conditions, and I am in the habit of disregarding the opinion that flowers are not frequently visited by insects in all cases where I am satisfied that nectar is secreted. When nectar alone is such an effective agent in securing insect visits the fact that flowers display even the least advertisement in the way of conspicuously colored parts is conclusive proof of the extreme importance of insect aid.

The following visitors of Xanthoxylum were taken on four days, between Apr. 12th and 19th:

HYMENOPTERA.—*Apidæ:* (1) Apis mellifica L. ☿, s. and c. p., ab.; (2) Ceratina tejonensis Cr. ♂, s.; (3) Osmia lignaria Say ♂♀, s., ab.; (4) O. albiventris Cr. ♂, s., ab.; (5) Nomada luteola Lep. ♂♀, s., ab.; (6) N. maculata Cr. ♂♀, s., ab.; *Andrenidæ:* (7) Andrena sayi Rob. ♂, s., ab.; (8) A. pruni Rob. ♂♀, s., freq.; (9) A. cressonii Rob. ♂♀, s., ab.; (10) A. flavo-clypeata Sm. ♂♀, s., ab.; (11) A. rugosa Rob. ♂, s.; (12) A. mariæ Rob. ♂, s.; (13) A. claytoniæ Rob. ♂♀, s., ab.; (14) Halictus sp. ♀, s.; (15) H. gracilis Rob. ♀, s., freq.; (16) H. arcuatus Rob. ♀, s.: (17) H. lerouxii Lep. ♀, s.; (18) H. ligatus Say ♀, s.; (19) H. cressonii Rob. ♀, s.; (20) H. zephyrus Sm. ♀, s., freq.; (21) H. caeruleus Rob. ♀, s., freq.; (22) H. confusus Sm. ♀, s., freq.; (23) H. stultus Cr. ♀, s. and c. p., ab.; (24)

Augochlora pura Say ♀, s.; (25) Colletes inæqualis Say ♂♀, s., ab.

DIPTERA.—*Syrphidæ:* (26) Chrysogaster nitida Wd.; (27) Syrphus americanus Wd.; (28) Xanthogramma felix O. S.; (29) Mesograpta geminata Say; (30) Sphærophoria cylindrica Say; (31) Eristalis dimidiatus Wd.; (32) Helophilus similis Mcq.; *Tachinidae:* (33) Jurinia apicifera Wlk.; (34) Gonia exul Will., ab.; (35) G. frontosa Say, ab.; *Muscidae:* (36) Lucilia cæsar L.; (37) L. cornicina F. freq.; *Cordyluridae:* (38) Scatophaga squalida Mg.—all sucking.

LEPIDOPTERA.—*Noctuidae:* (39) Plusia simplex Gn., s.

RHUS GLABRA L. — The greenish-yellow flowers are crowded in dense terminal panicles. Each flower forms a broad, shallow cup, in the bottom of which is situated a broad, yellow, five-lobed disc, which secretes nectar. In the pistillate flower access to the disc is impeded only by the style with its three large stigmas, and by small tufts of hairs on the inner faces of the five petals. In the staminate flower the disc is somewhat concealed by the large anthers.

As far as observed this species seems to be diœcious. In the patch of plants on which most of the insects were taken I found only pistillate flowers. I have also found patches in which all of the flowers appeared to be staminate, and in which, after the flowers fell, no fruit was to be seen, but only the naked axes of the panicles.

I have noted the flowers in bloom from June 8th to 24th. On account of the convenient nectar they are visited by numerous insects, mostly short-tongued Hymenoptera and Diptera, as shown in the following list, which contains insects noted on the flowers on three days, June 22d to 24th.

HYMENOPTERA.—*Apidae:* (1) Apis mellifica L. ☿, s., ab.; (2) Ceratina dupla Say ♀, s. and c. p.; (3) Heriades carinatum Cr. ♂♀, s. and c. p.; *Andrenidae:* (4) Andrena crataegi Rob. ♀, s.; (5) Halictus arcuatus Rob. ♀, s. and c. p., ab.; (6) H. parallelus Say ♀, s.; (7) H. lerouxii Lep. ♀, s.; (8) H. fasciatus Nyl. ♀, s.; (9) H. pilosus Sm. ♀, s. and c. p.; (10) H. pruinosus Rob. ♂♀, s.; (11) H. confusus Sm. ♂♀, s. and c. p., ab.; (12) H. zephyrus Sm. ♀, s. and c. p.; (13) H. stultus Cr. ♀, s. and c. p., ab.; (14) Augochlora pura Say ♀, s. and c. p.; (15) Agapostemon bicolor Rob. ♀, s. and c. p.; (16) A. radiatus Say ♀, s.; (17) Colletes willistonii Rob. ♂♀, s., freq.; (18)

C. eulophi Rob. ♂♀, s., freq.; (19) Prosopis affinis Sm. ♂, s. and f. p.; *Vespidae:* (20) Polistes metricus Say, s.; *Eumenidae:* (21) Odynerus anormis Say, s.; *Crabronidae:* (22) Oxybelus frontalis Rob., s.; (23) O. emarginatus Say, s.; *Mimesidae:* (24) Mimesa proxima Cr., s.; *Philanthidae:* (25) Cerceris robertsonii Fox, s., freq.: (26) C. compacta Cr., s., freq.; *Sphecidæ:* (27) Ammophila gryphus Sm., s.; (28) A. vulgaris Cr., s.; (29) Isodontia philadelphica Lep., s.; (30) Priononyx thomæ F., s.; *Pompilidae:* (31) Pompilus marginatus Say, s.; *Braconidae:* (32) Vipio robertsonii Ashm. (MS.), s.

DIPTERA.—*Empidae:* (33) Empis sp., s.; *Conopidae:* (34) Physocephala tibialis Say, s.; (35) Zodion nanellum Lw., s.; *Syrphidae:* (36) Syrphus ribesii L., s. and f. p.; (37) S. americanus Wd., s. and f. p.; (38) Mesograpta marginata Say, s. and f. p., freq.; (39) M. geminata Say, s. and f. p.; *Tachinidae:* (40) Ocyptera euchenor Wlk., s.; (41) Jurinia apicifera Wlk., s., ab.; (42) J. smaragdina Mcq., s.; (43) Belvosia bifasciata F., s.; (44) Trichophora echinomoides Twns., s.; (45) Sarcomacronychia aurifrons Twns., s.; (46) Masicera sp., s.; (47) Acroglossa hesperidarum Will., s.; *Sarcophagidae:* (48) sp., s.; (49–52) Sarcophaga spp., s.; *Muscidae:* (53) Stomoxys calcitrans L., s.; (54) Lucilia cornicina F., s.; (55) L. sylvarum Mg., s.; *Anthomyidae:* (56–57) Chortophila spp., s.

COLEOPTERA.—*Mordellidae:* (58) Mordella marginata Melsh., s.

Carlinville, Ill.

J. H. Burkill
from the author

[FROM THE BOTANICAL GAZETTE, Vol. XX.]

Flowers and insects. XIII.[1]

CHARLES ROBERTSON.

DODECATHEON MEADIA L.—American cowslip, shooting-star. In his arrangement of floral mechanisms Delpino (2) recognizes a class of pendulous nodding or horizontal flowers upon which the visitors cling (apparrecchi prensili), which he divides into the borrage and the verbascum types (tipo borragineo, tipo verbascino). The former includes such flowers as *Dodecatheon*, *Cyclamen*, and *Solanum*, which the bees clasp in such a way as to receive the pollen upon the undersides of their bodies, and the latter contains flowers like *Verbascum* and *Tradescantia*, which are provided with hairs which afford a foot-hold.

Kerner (1) regards the reflexed petals as facilitating access to nectar and pollen, and this is true as regards the legitimate visitors. Intruders are much more effectually excluded than would be the case if the petals were less strongly reflexed, as in the flowers of *Erythronium*.[2] The approximation of the anthers in a compact cone also gives the flower a signal advantage over such a flower as *Ribes gracile*,[3] whose stamens being of the ordinary form permit the visits of a number of insects which the flower cannot utilize. The reflexed petals also render the nodding flowers much more conspicuous and attractive than they would be if the expanded petals faced the ground.

Loew (3) has figured and thoroughly described *Dodecatheon integrifolium* Michx. (=*D. Meadia* L.), *D. Jeffreyi* Moore (=*D. Meadia* var. *lancifolium* Gray), and an unnamed species from material growing in the Berlin Garden. To this I shall add an account of *D. Meadia* as observed under natural conditions in Illinois. The plant is common in prairies and open woods, where it grows in rather large patches. The scapes rise from 3 to 6^{dm} and bear numerous, handsome flowers, which are white or rose color. The corolla has a short tube, which for

[1]Contributions to an account of the ecological relations of the entomophilous flora and the anthophilous insect fauna of the neighborhood of Carlinville, Illinois.

[2]Bot. Gaz. **17**:69. 1892.

[3]Ibid., 270.

about 3^{mm} is united with a tube formed by the monadelphous filaments. After separating from the stamen tube it is bent upon itself, and its lobes are strongly reflexed. At the flexure it is strongly thickened and marked with dark reddish purple. This portion of the corolla forms a foot-hold for the bees to cling to while sucking. The tube formed by the united filaments is about 5^{mm} long. The anthers are very rigid and are so closely approximated that they form a cone from 8 to 10^{mm} long. Exteriorly the stamen-tube is yellow, but the base of each anther is swollen and marked with dark purple. This part also serves as a foot-hold and as a path-finder. The stamen-tube with its cone of rigid anthers serves to conceal the nectar and to render it quite deep seated, for to reach the sweets the bees must force their proboscides between the anther tips.

The flowers are homogamous. Cross-pollination is secured by the stigma being 2 or 3^{mm} in advance of the anthers and having its surface directed away from them. According to Loew (3) spontaneous self-pollination may occur when the corolla falls.

During the blooming season, April 24 to May 24, the plant is in competition more or less severe with the following flowers, which are also adapted to bumblebees, no mention being made of those whose seasons overlap for only a short time with the first or last part of the season of *Dodecatheon:*

Delphinium tricorne, Geranium maculatum, Aesculus glabra, Astragalus Mexicanus, Baptisia leucophaea, Pyrus coronaria, Rubus villosus, R. Canadensis, Triosteum perfoliatum, Hydrophyllum Virginicum, Mertensia Virginica, Pentstemon pubescens, Monarda Bradburiana, Orchis spectabilis, Uvularia grandiflora and the introduced Trifolium pratense, Robinia Pseudacacia and Nepeta Glechoma.

The phaenological position of *Dodecatheon* exposes its flowers to bumblebee females, the workers only beginning to appear as the blooming time expires. It coincides pretty nearly with the flight of *Anthophora ursina*, and later overlaps with the early part of the flight of *A. abrupta*. *Synhalonia speciosa* and *S. belfragei* and *Osmia bucephala* fly throughout the period. These are the only long-tongued bees which could be expected to visit the flowers in my neighborhood. May 2, 5 and 8 I saw the flowers visited by the following:

Hymenoptera—*Apidæ:* (1) Bombus americanorum F. ♀, s., ab.; (2) Anthophora ursina Cr. ♀, s. and c. p.; (3) Synhalonia speciosa Cr. ♂, s., *Andrenidæ:* (4) Augochlora pura Say ♀, c. p., one.

Lepidoptera—*Rhopalocera:* (5) Colias philodice Gdt., s.

On the literature of *Dodecatheon* see:—

(1) Kerner, Die Schutzmittel des Pollens gegen die Nachtheile vorzeitiger Dislocation und gegen die Nachtheile vorzeitiger Befruchtung 38. 1873. Sep. a. d. Berichten des naturw. med. Vereines zu Innsbruck 2 and 3:—.1872.—(2) Delpino, Ulteriori osservazioni sulla dicogamia nel regno vegetale Pt. 2. fasc. 2: 295. 1875. Estratto dagli Atti della Soc. Ital. delle Sci. Nat. in Milano 16 and 17:—.1873-1874.—(3) Loew, Blüthenbiologische Beiträge I. 17-21. Sep. aus Pringsheim's Jahrbucher 22:—.1891. (Abstract in Just's Bot. Jahresbericht 19^1: 416.)

STEIRONEMA CILIATUM Raf.—The observations which have been recorded seem to show that the adaptation for cross-pollination in *Lysimachia* and *Steironema* consists in the stigma being so far advanced above the anthers that self-pollination never or rarely occurs, as in Müller's large form of *L. vulgaris* (3, 16), or from proterogyny, as in *L. thyrsiflora* (Warming 10 and MacLeod 24) and in our *S. lanceolatum*, *longifolium* (23) and *ciliatum*. A less conspicuous form of *L. vulgaris*, which grows in situations unfavorable for insect visits is regularly self-fertile. Other species are homogamous and self-pollinating, as *L. nummularia* (Warming 10) and *nemorum* (Kerner 22).

According to Bonnier (11) in *L. vulgaris* nectar is secreted by the ovary and escapes through stomata in the epidermis, but in most cases it is wanting, or exists in quantity imperceptible by ordinary means, though the visits of male bees seem to indicate its presence (3, 16, 23). The part played by the papillæ in the attraction of insects (Kerner 22) is even more doubtful. I have seen no evidence of this in our species. The pollen is by far the most important, for by attracting the females of *Macropis* it has given rise to an interesting case of mutual economic correlation. Our species of *Steironema* (23) and the European *L. vulgaris* (3, 16, 24, 27) and *punctata* (4) are visited almost exclusively by bees of this

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[4] As a substitute for a more extended review it is proposed to give an index to the literature of each genus, arranged chronologically, and it is hoped that the index will contain at least the principal references. Use has been made of the Bibliography compiled by D'Arcy W. Thompson, published in the translation of Müller's Befruchtung der Blumen, and giving the titles of books, etc. published up to 1883; of MacLeod's continuation of Thompson's list for the period 1883-1889, Bot. Jaarboek, 1890; of the abstracts by Müller and Dalla Torre in Just's Bot. Jahresbericht and those of Ludwig and others in the Bot. Centralblatt. I am under obligations to Prof. Wm. Trelease for access to the literature contained in the library of the Missouri Botanical Garden.

Abstracts are not cited unless they contain information on the genus being indexed. Information about contents of papers, etc., when given in the text, is not repeated in the index.

genus. I have mentioned (23) the flowers on which species of *Macropis* have been observed. Patton (12) states that Dufour found both sexes of *M. labiata* on flowers of *Alisma plantago*, and Schenk one or both on *Bryonia*, *Rubus caesius*, *Cirsium arvense* and *Picris*, but no one has seen a female *Macropis* collecting pollen of any flower except *Lysimachia* and *Steironema*.

Steironema ciliatum agrees in all essential particulars with *S. lanceolatum* (23). It grows taller and has larger flowers. In Connecticut Patton (13) saw the flowers visited by *Macropis ciliata* Pttn. ♀ and by *M. patellata* Pttn. ♂. In Illinois I have seen them visited by *M. steironematis* Rob. ♂♀, the female collecting pollen. The latter bee does not seem to have a decided preference for yellow, for all of the other flowers I have taken it on are white (23).

On the literature of *Lysimachia and Steironema* see:—

(1) Sprengel, Das entdeckte Geheimniss der Natur im Bau und in der Befruchtung der Blumen. 1793. *L. quadrifolia* and *vulgaris*, 104. —(2) Kerner, Die Schutzmittel des Pollens 27. 1873.—(3) Müller, Befruchtung der Blumen durch Insekten 1873. *L. vulgaris* and *nummularia*, 348–9.—(4) Delpino, Ulteriori osservazioni nel sulla dicogamia regno vegetale Pt. 2. fasc: 1: 212, 321. Estr. dagli Atti della Soc. Ital. d. Sci. Nat. 17:—.1874. Visits of *Macropis* to *L. vulgaris* and *punctata* observed by Piccioli, Müller and Delpino in Westfalia, at Firenze and Vallombrosa.—(5) Lubbock, British wild flowers considered in relation to insects. 1875. *L. vulgaris*, visits of *Macropis*, 21; Müller's two forms, 126.—(6) Darwin, The variation of animals and plants under domestication 2: 154. 1876. 2d edit. *L. nummularia*, sterility.—(7) Darwin, The different forms of flowers on plants of the same species. 1877. *L. vulgaris*, Müller's two forms, 4, 342.—(8) Müller, Das Variiren der Grösse gefärbter Blüthenhüllen und sein Einfluss auf die Naturzüchtung der Blumen. Kosmos 2: 11–25, 128–139. 1877. *L. vulgaris*. (Abstract in Just's Bot. Jahresbericht 5^1: 740.)—(9) Henslow, On the self-fertilization of plants. Trans. Linn. Soc. II. Bot. 1: 328, 377. *L. vulgaris*, Müller's two forms. 1877.—(10) Warming, Smaa biologiske og morfologiske bidrag. Bot. Tidsskrift III. 2: 108–130. 1877. (Just's Bot. Jahresbericht 5^1: 745–6.)—(11) Bonnier, Les Nectaires. Extrait des Ann. des Sci. Nat. Bot. VI. 8: 140. 1879. (Just's Bot. Jahresbericht 7^1: 120.)—(12) Patton, Observations on the genus Macropis. Am. Journ. Sci. and Arts. III. 18: 211–14. 1879. *L. vulgaris* and *S. ciliatum*. (Just's Bot. Jahresbericht 7^1: 145.)—(13) Patton, Description of the species of Macropis. Ent. Monthly Magazine 17: 32–33. 1880.—(14) Dufour, Existence de tensions chez certaines fleurs. Etude d' anatomie et de physiologie végétales, desertation inaugurale, 42–46. 1882. (Just's Bot. Jahresbericht 9^1: 500.)—(15) Müller, Weitere Beobachtungen über Befruchtung der Blumen durch-Insecten 3: 65. 1882. Scp. aus dem Verh. des naturhist. Ver. der. preuss. Rheinl. u. Westf. *L. vulgaris*, visitors.—(16) Müller, The fertilization of flowers

389–390. 1883. *L. vulgaris*, pollination, *L. nummularia* and *thyrsiflora*, ref. (6) and (10).—(17) MacLeod, Untersuchungen über die Befruchtung einiger phanerogamen Pflanzen der Belgischen Flora. Bot. Centralblatt 23: 366. 1885. *L. vulgaris*, autogamy. (Just's Bot. Jahresbericht 13[1]: 740.)—(18) MacLeod, Nouvelles recherches sur la fertilisation de quelques plantes phanérogames. Arch. de Biol. 7: 156. 1886. *L. vulgaris*.—(19) Kirchner, Neue Beobachtungen über die Bestäubungseinrichtungen einheimischer Pflanzen. Progr. des 68 Jahresfeier der kgl. Württemb. landwirtsch. Akademie Hohenheim. 1886. *L. nemorum*, no nectar. (Just's Bot. Jahresbericht 14[1]: 791.)—(20) Jordan, Die Stellung der Honigbehälter und die Befruchtungswerkzeuge in den Blumen 51. Sep. aus Flora 69: 1886. *L. punctata*, nectar receptacles of doubtful occurrence.—(21) Halsted, Observations upon pollen measurements. Bull. Torr. Bot. Club 16: 135. 1889. *S. lanceolatum*, (Just's Bot. Jahresbericht 17[1]: 523.)—(22) Kerner, Pflanzenleben. 2:—. 1891. (Just's Bot. Jahresbericht 17[1]: 528. 18: 484.) *L. ciliata* Protection of pollen by nodding of fls., 118. *L. thyrsiflora*, *ciliata*, attraction by papillæ, 166. *L. nemorum*, spontaneous self-pollination, 338. *L. nummularia*, 398.—(23) Robertson, Flowers and insects. X. Bot. Gaz. 18 47–48. 1893. *S. lanceolatum*, *longifolium*, *ciliatum*, *L. quadrifolia*, *vulgaris*, *nemorum*, *nummularia*. (Bot. Centralblatt 55 101.)—(24) MacLeod, Over de bevruchting der bloemen in het Kempisch gedeelte van Vlaanderen. Bot. Jaarboek 5: 443–444. 1893. *L. vulgaris*, *nemorum*, *nummularia*, *thyrsiflora*. (Bot. Centralblatt 56: 177.)—(25) Knuth, Blumen und Insekten auf den Nordfriesischen Inseln 120. 1894. *L. vulgaris*, autogamous form on Sylt.—(26) Loew, Blütenbiologische Floristik des mittleren und nördlichen Europa sowie Grönlands. 1894. *L. vulgaris*, 161. *L. nummularia*, *nemorum*, *thyrsiflora*, *ciliata*, 319.—(27) Knuth, Weitere Beobactungen über Blumen und Insecten auf den Nordfriesischen Inseln. Schr. d. Nat. V. f Schleswig-Holstein 10: 229, 239. 1895? Correlated presence or absence of *Macropis* and *Lysimachia* on certain islands, etc.

ENSLENIA ALBIDA Nutt.—The plants are common on creekbanks, often climbing high, and blooming from July 12th to August 22. The flowers are white and are arranged in small umbel-like clusters. The petals are erect, and their tips are bent aside, out of the way of the passage leading to the nectar. The divisions of the crown are petal-like and erect, the central portion being produced above into two long appendages. On each side there is a wing-like portion which is grooved on the inner face, where the nectar is secreted and lodged. Each wing-like part, with the one of the next division forms a more or less well defined passage, which guides the bee's proboscis to the nectar. This is situated so near the angles of the wings of the approximated anthers that, when the proboscis is withdrawn, some slender appendage is quite likely to be caught between the divergent angles of the anther wings and guided by them into the cleft of the little black corpusculum which lies at the top of the slit. The gynostegium is quite slender and is tipped by five white

appendages. These, with the ten flexuous tips of the crown divisions and the five erect petals, give the flower a soft, white appearance and conceal the complicated mechanism within, while they also render a little more evident the passage which leads to the nectar.

When a corpusculum with its pair of pollinia is withdrawn, it shows an unusually short retinaculum, which from its attachment to the corpusculum curves outward and a little downward and is inserted a little below the apex of the pollinium. The apex of the pollinium thus forms a very conspicuous knee, which stands at right angles to the axis of the corpusculum, and this knee is the part which is caught by the anther wings and thus causes the insertion of the pollinium. I find no evidence whatever that the original appendage to which the corpusculum becomes attached ever again enters the slit, or that the pollinia are introduced in pairs. When the pollinia are thoroughly dried, their planes are commonly perpendicular to each other, or they sometimes lie in nearly the same plane. The knees, therefore, project in different directions, and this increases the chances of one of the pollinia being inserted into the stigmatic chamber. There is nothing to render it probable that the bee's proboscis will be introduced in the same relative position, and so there is no advantage in both of the knees, or either of them, turning to the same side. In *Asclepias* and *Acerates*, in which the corpuscula are usually attached to short hairs on the legs, or other parts of the body, as in *Acerates longifolia*,[5] it is important that the knees should turn away from the part to which they are attached, for this is the only side on which they are likely to be caught by the anther wings. In large flowers, like *Asclepias Sullivantii*, in which the corpuscula are attached to the bee's claws, the bees commonly clasp the flowers so that the legs are guided upwards between the hoods. The movement of the knees which brings them near together results in turning them inwards, in which position they are more likely to be brought to the stigma. In *Enslenia* the corpuscula are attached so near to the end of the proboscis that there does not seem to be any advantage in turning in any particular direction, though they are slightly turned towards the side on which the corpusculum is attached.

Müller and Corry erroneously supposed that the movement

[5] Bot. Gaz. **12**: 245. 1887.

of the pollinia of *Asclepias*, which approximates them, is intended to facilitate the introduction of both pollinia into the same stigmatic chamber. In *Cynanchum vincetoxicum*,[6] whose mechanism in a general way resembles that of *Enslenia*, Müller states that the retinacula bend so that the pollinia come close together. The flowers are adapted to carrion flies, Muscidæ, Sarcophagidæ, etc., and I suspect that the movement is merely to turn the knees away from the proboscis. Müller's account of the pollination of *Cynanchum* seems to me to be just as erroneous as that of *Asclepias Cornuti*. In the normal pollination of any asclepiad I doubt if it can be shown either that the part to which the corpusculum is attached is again caught by the wings, that the corpusculum ever enters the slit, or that both pollinia together are ever introduced into the same stigmatic chamber.

The flowers of *Enslenia* are visited principally by bees of the genus *Halictus*. These insects readily remove the corpuscula, which are found attached to the palpi, the tips of the laminæ, or other fine divisions of the proboscis. *Myzine sexcincta* was abundant on the flowers, but I could find no examples bearing corpuscula. The following list was taken on July 14th, 20th, and August 22d; the insects bearing corpuscula are indicated by !

Hymenoptera—*Andrenidæ:* (1) Prosopis pygmaea Cr. ♂; (2) P. modestus Say ♀, !; (3) Halictus confusus Sm. ♂♀, ab., !; (4) H. zephyrus Sm. ♂♀, ab., !; (5) H. stultus Cr. ♂♀, ab., !; (6) H. tegularis Rob. ♂♀, !; (7) H. cephalicus Rob. ♀; (8) H. platyparius Rob. ♀; (9) Augochlora viridula Sm. ♂♀; *Eumenidæ:* (10) Odynerus sp.; *Scoliidæ:* (11) Myzine sexcincta F., ab.

Diptera—*Empidæ:* (12) Empis clausa Rob. MS; *Bombylidæ:* (13) Anthrax fulvohirta Wd., !

Carlinville, Ills.

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[6] Müller. Alpenblumen, 350. Fertilization of Flowers, 401.

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from the author.

Flowers and insects. XIV.

CHARLES ROBERTSON.

GENTIANA PUBERULA Michx.—From the abundant observations on European species of *Gentiana* it appears that most of the species which have been investigated are proterandrous, though several are homogamous and a few proterogynous. Most of them are adapted to bumblebees, many to Lepidoptera, while quite a number are intermediate, being visited by both kinds of insects. One species, *G. lutea*, has exposed nectar, and is visited by a miscellaneous list. Nothing has been done with our species, except *G. crinita* and *Andrewsii*.

In the case of *G. Andrewsii*, Beal (6) observed that it was visited by bumblebees, but overlooked the proterandry, supposing that cross-pollination was favored by the stigma standing far above the anthers. A statement of Meehan, that the flower never opens, evidently taking it for granted that it is never visited by insects, is quoted by Henslow (12) in spite of Beal's observations. Vausenburg (10) objects to Beal's conclusions, and supposes that the stigma is pollinated as it passes the anthers. Kunze (18) regards the flower as cleistogamous, the nectar being of no significance. Bailey (17) records that nectar is secreted by the walls of the corolla. Gray (19, 21, 25) states that the flower opens a short time in sunshine, which I have never observed; notes the proterandry and that spontaneous self-pollination may finally occur by the lobes of the stigma curling back until they touch the anthers. Finally I have shown the adaptation to bumblebees and have recorded the abundant visits of *Bombus americanorum* F. ♂♀☿ (41). According to Beal (6) *G. crinita* is visited by bumblebees and resembles *G. Andrewsii*, of which, however, as we have noted, he had failed to recognize the proterandry.

G. Andrewsii and *puberula*, the only species I have found in my neighborhood, are the very latest of the bumblebee flowers, the former beginning to bloom by September 14th, and the latter on the 27th, both running nearly through October.

Gentiana puberula has the stem terminated by a cluster of

handsome bright blue flowers. The corolla measures about 5^{cm}, and the lobes expand horizontally about 3.5^{cm}. The tube is narrowed for about 17^{mm}, the bases of the filaments being attached to the tube for that distance. The free ends of the filaments bend inwards, holding the anthers in a cluster around the style. Bees insert their proboscides between the filaments, and these organs must be 17^{mm} long to exhaust the nectar. The flowers are strongly proterandrous and are adapted to bumblebees. I have seen them visited by *Bombus americanorum* F. ♂☿.

While the flowers of this plant are more conspicuous than those of *G. Andrewsii*, their pollen is not so well protected. Small bees and flies may enter the corollas and remove the pollen without being of any service, but this is prevented in *G. Andrewsii* by the lobes remaining closed.

On the literature of Gentiana see:

(1) Sprengel, Das entdeckte Geheimniss, 150–2. 1793. *G. Pneumonanthe*, proterandry, etc.—(2) Axell, Om anordningarna för de fanerogama växternas befruktning. 1869. *G. Pneumonanthe*, 27, ref. (1). *G. nivalis, lingulata*, homogamous, etc., 101.—(3) Ricca, Osservazioni sulla fecondazione incrociata dei vegetali alpini e subalpini. Atta della Soc. Ital. di Scienze naturale **13**: 254–63. 1870. **14**: 245–64. 1871. *G. acaulis, germanica, verna.*—(4) Kerner, Schutzmittel des Pollens 26, 44. 1873.—(5) Müller, Befruchtung der Blumen 332–3. 1873. *G. Pneumonanthe, Amarella*, pollination.—(6) Beal, The fertilization of gentians by humblebees. Am. Nat. **8**: 180, 226. 1874.—(7) Meehan, Fertilization of Gentiana. Proc. Acad. Nat. Sci. Philad. **1874**: 160. Proterandry, closed fl. seems to make insect pollination difficult.—(8) Delpino, Ulteriori osservazioni, Pt. II. 2: 162, 173, 180. 1875. *G. acaulis, asclepiadea, ciliata, pannonica*, nectar receptacle and guides, proterandry, etc.—(9) Lubbock, British wild flowers in relation to insects, 29, 127. 1875. *G. Pneumonanthe, Amarella.*—(10) Vausenburg, Gentiana Andrewsii. Am. Nat. **9**: 310. 1875.—(11) Kerner, Die Schutzmittel der Blüthen gegen unberufene Gäste. Festschrift Zool.-Bot. Gesellsch. Wien. 1876. Several spp.—(12) Henslow, On the self-fertilization of plants. Trans. Linn. Soc. II. Bot. **1**: 326. 1877. Self-pollination by retention of corolla.—(13) Müller, Alpine species of Gentiana. Nature **15**: 317–19, 473–5. *f. 94–115*. 1877. Several spp.—(14) Müller, Geschichtliche Entwickelung der Gattung *Gentiana*. Kosmos **1**: 162–3. 1877. Abstract of (13)—(15) Müller, Fertilization of flowers by insects. Nature **16**: 265. 1877. *G. Bavarica, verna*, visits of Macroglossa.—(16) Burton, Gentiana asclepiadea and bees. Nature **17**: 201–2. 1877. Perforation.—(17) Bailey, Notes from Rhode Island. Bull. Torr. Bot. Club. **6**: 173. 1877.—(18) Kunze, Cleistogene flowers. ibid. 174. 1877.—(19) Gray, Gentiana Andrewsii. ibid. 179. 1877.—(20) Meehan, Gentiana Andrewsii. ibid. 189. 1877. Stigma receptive after becoming exposed above corolla, etc.—(21) Gray, Note to the review of Darwin's "Forms of Flowers." Am. Jour. Sci. and Arts. III. **15**: 221. Reply to (20).—

(22) Müller, Die Insekten als unbewusste Blumenzüchter. Kosmos **3**: 407, 425, 482. 1878. *G. Bavarica, excisa, lutea, verna.*—(23) Müller, Die Wechselbeziehungen zwischen den Blumen und den ihre Kreuzung vermittelden Insekten. Encycl. der Narturwiss. Breslau **5**: 62. 1879. *G.* subgen. *Cyclostigma*, change from bumblebee to butterfly fls. in Alps.—(24) Bonnier, Les Nectaires. 1879. *G.*, 116, *campestris*, 143.—(25) Gray, Structural Botany 240. 1880.—(26) Müller, Bombus mastrucatus, ein Dysteleolog unter den alpinen Blumensuchern. Kosmos **5**: 422–31. 1880. *G. acaulis, asclepiadea, campestris*, perforation. —(27) Müller, Die Falterblumen des Alpenfrühlings und ihre Liebesboten. Kosmos **6**: 446–56. 1880. *G. verna.*—(28) Thompson, Fertilization of New Zealand flowering plants. Trans. & Proc. New Zeal. Inst. **13**: 241–88. 1880. *G. montana*, proterandrous, etc.—(29) Müller, Die Alpenblumen, ihre Befruchtung durch Insekten, und ihre Anpassungen an dieselben 329–49. 1881. *G. acaulis, asclepiadea, Bavarica, campestris, ciliata, lutea. nana, nivalis, obtusifolia, punctata, tenella, verna*, with notes on others and review of genus.—(30) Müller, Die Entwickelung der Blumenthätigkeit der Insekten. Kosmos **9**: 258–72, 351–70. 1881. *G. acaulis, Bavarica, punctata, verna.*—(31) Müller, Fertilization of flowers. 402–6. 1883. *G. Pneumonanthe, Amarella*, notes on others and review of genus.—(32) Warming, Om Nogle Arktiske Vaexters Biologi. Bihang till K. Svenska Vet.-Acad. Handlingar **12**: 8–12. 1886. *G. nivalis, tenella, Pneumonanthe, involucrata, Amarella, campestris.*—(33) Loew, Weitere Beobachtungen über den Blumenbesuch von Insekten an Freilandpflanzen des botanischen Gartens zu Berlin. Jahrb. bot. Gartens Berlin **4**: 128–9. 1886. *G.*, Müller on development of.—(34) Huxley. The gentians. Notes and queries. Journ. Linn. Soc. **24**: 101–24. 1887. On the family.—(35) Lindman, Blühen und Bestäubungseinrichtungen im Skandinavischen Hochgebirge. Bot. Centralblatt **30**: 159. 1887. *G. campestris, nivalis*, self-pollination.—(36) Pammel, On the pollination of Phlomis tuberosa and the perforation of flowers. Trans. St. Louis Acad. Sci. **5**: 257–8, 474. 1888. Perforation.—(37) Schulz, Beiträge zur Kenntniss der Bestäubungeinrichtungen und Geschlechtsvertheilung bei den Pflanzen. I. 1888. II. 1890. Bibliotheca Botanica. I. *G. germanica, Amarella, ciliata*, II. *G. acaulis, excisa, verna, campestris, obtusifolia, ciliata*, also 14 spp. perforated by Bombus.—(38) Hansgirg, Ueber d. Verbreitung d. reizbaren Staubfäden u. Narben, sowie d. sich periodisch oder blos einmal öffenden u. schliessenden Blüten. Bot. Centralblatt **43**: 415. 1890. *G. acaulis, Saponaria*, opening and closing of fls.—(39) Kirchner, Beiträge zur Biologie der Blüthen. Progr. z. 72 Jahresfeier d. Kgl. Würtemb. landwirthschaftl. Akademie Hohenheim 47–49. 1890. *G. purpurea, tenella.*—(40) Kerner, Pflanzenleben **2**: 1891. Several spp.—(41) MacLeod, De Pyreneeënbloemen en hare bevruchting door insecten. 1891. *G. verna*, visitors, 343.—(41) Robertson, Flowers and insects. Asclepiadaceæ—Scrophulariaceæ. Trans. St. Louis Acad. Sci. **5**: 577. 1891.—(42) Hansgirg, Neue biologische Mittheilungen. Bot. Centralblatt **52**: 387. 1892. *G. phlogifolia, Fetisowii*, opening and closing of fls.—(43) Hansgirg, Biologische Fragmente. Bot. Centralblatt **56**: 258. 1893. *G. campestris.* opening and closing of fls.—(44) MacLeod, Over de bevruchting der bloemen in het Kempisch gedeelte van Vlaanderen. Bot. Jaarboek **5**: 381. 1893. *G. Pneumonanthe.*—(45) Knuth, Blumen und In-

sekten auf den Nordfriesischen Inseln 105. 1894. *G. Pneumonanthe.*—(46) Loew, Blütenbiologische Floristik des mittleren und nördlichen Europa sowie Grönlands. Systematische Zusammenstellung des in den letzten zehn Jahren veröffentlichten Beobachtungsmaterials. 1894. 25 species.

FRASERA CAROLINENSIS Walt.—American columbo.—In the GAZETTE **18**: 48–9, the view was expressed that the hairy crest about the nectaries serves as a foothold, besides concealing the nectar. Its importance as a foothold, however, is not great. It was also supposed that bumblebees might prove to be the principal guests, though they had not been observed about the flowers at that time. In 1894 the flowers were in bloom from May 24th to June 22nd. On May 30th and June 1st, 4th, 8th and 12th the following visitors were noted:

Apidæ: (1) Apis mellifica L. ☿, ab.; (2) Bombus separatus Cr. ♀☿, the most abundant visitor; (3) B. americanorum F. ♀, one; (4) Anthophora abrupta Say ♂♀, freq.

Rhopalocera: (5) Eudamus pylades Scud.—all sucking.

Several species of Andrenidæ, principally *Halictus* and *Augochlora*, visit the flowers for nectar and pollen, but are too small to effect pollination.

PHLOX GLABERRIMA L.—This plant is rather rare. It grows on prairies and was noted in bloom from May 28th to July 30th. The stems grow from 4 to 8^{dm} high, bear handsome corymbs of purple flowers and are often collected in large patches. The border expands about 20^{mm}, and the tube is from 16 to 18^{mm} long. There is a slight appearance of proterandry, but I think that, in case insect visits fail, spontaneous self-pollination may occur by the stigma receiving pollen from the nearest anthers. There is a chance that an insect's proboscis may carry pollen from the long stamens back to the stigma, though the anthers of the long stamens dehisce first. This species agrees with all of the species of *Phlox* which have been observed in being adapted to butterflies. The anthers of the long stamens are so exposed at the mouth of the tube that their pollen is sometimes stolen by syrphids, *Syrphus americanus* Wd., etc. On seven days, between May 28th and July 18th, the following visitors were observed, all sucking:

Lepidoptera—*Rhopalocera:* (1) Danais archippus F.; (2) Colias philodice Gdt.; (3) Papilio thoas L.; (4) P. asterias F.; (5) P. philenor L.; (6) Pamphila peckius Kby.; *Heterocera:* (7) Scepsis fulvicollis Hbn.

PHLOX PILOSA L.—This species is common on prairies, growing in large patches. The flowers are pinkish. The border is about 20^{mm} wide, the tubes 10 to 15^{mm} long. The

style is very short. Self-pollination may be effected by insect aid or may occur spontaneously by the pollen falling in the tube. The frequent visits of insects, however, render cross-pollination inevitable.

The principal visitors are butterflies; but, as commonly occurs with such flowers, long-tongued bees and flies also seek the nectar. The shorter tubes render the nectar more convenient to these insects than in the case of *P. glaberrima.* The plant blooms from May 3d to June 29th. May 8th, 16th, 17th, 31st, and June 5th, the subjoined list was observed, all the insects sucking:—

Lepidoptera—*Rhopalocera:* (1) Phyciodes tharos Dru.; (2) Pyrameis huntera F.; (3) Chrysophanus thoe B.-L.; (4) Colias philodice Gdt.; (5) Papilio asterias F.; (6) Pamphila peckius Kby.; *Heterocera:* (7) Plusia simplex Gn.

Hymenoptera—*Apidæ:* (8) Bombus separatus Cr. ♀; (9) B. pennsylvanicus DeG. ♀; (10) B. americanorum F. ♀; (11) Synhalonia speciosa Cr. ♂♀.

Diptera—*Bombylidæ* (12) Bombylius atriceps Lw.

PHLOX DIVARICATA L.—This is the earliest *Phlox* in my neighborhood, blooming from April 10th to June 2d. I have given a list (14) of eleven species of Lepidoptera and four species of long-tongued bees taken on the flowers. To that list must be added the following:—

Lepidoptera—*Rhopalocera:* (16) Papilio thoas L.; (17) Eudamus tityrus F.; *Heterocera:* (18) Plusia simplex Gn.—all sucking.

On the pollination of Phlox see:

(1) Sprengel, Das entdeckte Geheimniss, 105. 1793. *P. paniculata,* proterandry, butterfly-fl.—(2) Darwin, Forms of Flowers 119–21, 287. 1877. *P. subulata,* doubtful heterostyly.—(3) Bonnier, Les Nectaires 118, 168. 1879. *P. Drummondii.*—(4) Bonnier et Flahault, Observations sur les modifications des végétaux suivant les conditions physiques du milieu. Ann. Sci. Nat. Bot. VI. 8:—1879. *P. Drummondii,* brilliancy of color changing with geographical distribution.—(5) Flahault, Nouvelles observations sur les modifications des végétaux suivant les conditions physiques du milieu. ibid. 9: 159–207. 1880. *P. Drummondii,* colored more lively in Sweden than at Paris.—(6) Francke, Einige Beiträge zur Kenntniss der Bestäubungseinrichtungen der Pflanzen. Inaug. Dessertation. Freiburg-i-B. 1883. *P. setacea.*—(7) Müller, Fertilization of flowers 407. 1883. *P. paniculata,* ref. (1), visitors.—(8) Walker, Insects and Flowers. Nature 28: 388–9 1883. *P. sp.*—(9) Loew, Beobachtungen über den Blumenbesuch von Insekten an Freilandpflanzen des Botanischen Gartens zu Berlin. Jahrb. bot. Gartens Berlin **3**: 85 (17). 1884, *P. reptans, subulata,* visits of Apis.—(10) Loew, Weitere Beobachtungen, etc. ibid. 4: 153, 1886. *P. paniculata,* visit of Echinomyia.—(11) MacLeod, Untersuch-

ungen über der Befruchtung der Blumen. Bot. Centralblatt 29: 119. 1887. *P. sp.*, visit of Plusia.—(12) Kerner, Pflanzenleben. 2: 111, 1891. Protection of pollen.—(13) Peter, Polemoniaceæ, Engler und Prantl, Die nat. Pflanzenfamilien 68: 40–48. 1891. Pollination.—(14) Robertson, Flowers and Insects. Asclepiadaceæ–Scrophulariaceæ, Trans. St. Louis Acad. Sci. 5: 578. 1891.—(15) Knuth, Blütenbiologische Herbstbeobachtungen. Bot. Centralblatt 49: 363. 1892. *P. acuminata*, vis. three butterflies.

LITHOSPERMUM CANESCENS (Mx.) Lehm.—According to Müller (4, 12, 13), *L. arvense*is homogamous and regularly self-pol-linated, though there is a chance of cross-pollination when the flower first opens. According to Kerner (18 Loew 21) it is slightly proterogynous, but Müller says the anthers begin to discharge their pollen before the flower opens. *L. purpureo-coeruleum* is slightly proterogynous, with anthers and stigma of equal height (17). *L. arvense* has small white flowers, rarely with blue (Loew 21) with tubes 4–5^{mm} long. Sprengel (1) saw it visited by butterflies, and Müller (4, 12, 13) observed as visitors two butterflies, two bees and two syrphids. *L. purpureo-coeruleum*, with red flowers changing to blue (17) and tubes 8–9^{mm} long (21), and *L. officinale* with small, dull white flowers, are classed by Loew (14) as bee-flowers. In the Berlin Garden the former is visited by *Anthophora pilipes* and *Osmia aenea*, and the latter by *Megachile willughbiella*.

Bebb (5) discovered that *L. longiflorum* is only the early state of *L. angustifolium*. This and *L. canescens* are early species which are able to attract insects until about the first of June (10), when probably on account of being over-shadowed by the trees or by the later more luxuriant vegetation, the latter goes out of bloom and the former continues to produce cleistogamic flowers. Bessey (10) concludes that *L. angustifolium* is not dimorphous, but highly variable, and Halsted (16) comes to about the same conclusion. In the case of *L. canescens*, Smith (9) seems to have regarded the flower as dimorphous, but found a rare third form with "flowers differing from the ordinary dimorphous condition." Bessey (10) regards it as a case of well marked dimorphism, though according to Darwin (11) the forms are variable and the case requires further investigation. Christy (15) mentions only two forms. Halsted (16) calls it decidedly dimorphic, saying he has seen no indication of trimorphism. At Madison, Wisconsin, Trelease (MS. notes) found only two forms and regarded

the species as truly dimorphic. I have not taken great pains to examine flowers, but in all cases examined I have found indication of nothing but dimorphism.

In my neighborhood, *Lithospermum canescens* is the earliest butterfly-flower, blooming from March 18th to June 12th. The stems, often several from the same base, rise from 1 to 3^{dm}. The racemes as they uncoil expose two or three erect orange-yellow flowers. The corolla is salver-form. The five-lobed border expands about 15^{mm}. The tube is about 8^{mm} long. At the throat it is narrowed to a diameter of about 1^{mm} by appendages whose purpose seems to be to restrict the visitors to slender tongues. The orange-yellow color and the narrow tube indicate an adaptation to butterflies, but the flowers are also visited by long-tongued bees. On April 30th, May 1st, 2nd, 17th, 20th, and June 5th the visitors observed were:

Lepidoptera—*Rhopalocera:* (1), Pyrameis huntera F.; (2) Chrysophanus thoe B.-L.; (3) Colias philodice Gdt., very ab.; (4) Papilio ajax L'; (5) P. asterias F.; (6) Nisoniades icelus Lint.

Hymenoptera—*Apidæ:* (7) Bombus americanorum F. ♀, ab.; (8) Synhalonia speciosa Cr. ♂ ♀, ab.; (9) Osmia cobaltina Cr. ♀, one.

Diptera—*Bombylidæ:* (10) Bombylius major L.—all sucking.

On the pollination of *Lithospermum* see:

(1) Sprengel, Das entdeckte Geheimniss 88. 1793.—(2) Kuhn, Einige Bemerkungen über Vandellia und den Blüthenpolymorphismus. Bot. Zeit. 25: 67. 1867. *L.*, heterostyled dimorphism in.—(3) Axell, Om anordningarna för de fanerogama växternas befruktning 22, 99. 1869. Ref. (2).—(4) Müller, Befruchtung der Blumen 270. 1873.—(5) Bebb, Lithospermum longiflorum only L. angustifolium. Am. Nat. 7: 691. 1873.—(6) Lubbock, British Wild Flowers in Relation to Insects 132. 1875. *L. arvense*, ref. (4)—(7) Henslow, On the self-fertilization of plants 375. 1877. *L. arvense*, ref. (6)—(8) Bonnier, Les Nectaires 125, 1879. *L. arvense.*—(9) Smith, Trimorphism in Lithospermum canescens. Bot. Gaz. 4: 168 1879.—(10) Bessey, The supposed dimorphism of Lithospermum longiflorum (L. angustifolium). Am. Nat. 14: 417–21. 1880.—(11) Darwin, Forms of flowers. 2nd edit. 1880. *L. canescens* and *longiflorum*, ref. (9) and (10).—(12) Müller, Weitere Beobachtungen 3: 16. 1882.—(13) Müller, Fertilization of Flowers 417–18. 1883. *L. arvense*, pollination. *L. canescens, longiflorum*, ref. (11)—(14) Loew, Beobachtungen über den Blumenbesuch von Insekten an Freilandpflanzen des Botanischen Gartens zu Berlin. 1884. *L. arvense*, 8. *L. purpureo-coeruleum*, 38, 49, *L. officinale*, 45.—(15) Christy, Heterostyled plants. Journ of Bot. 23: 49–50, 1885. *L. canescens, hirsutum*, relative abundance of long and short-styled fls.—(16) Halsted, Notes upon Lithospermum. Bot. Gaz. 14: 202–3. 1889.—(17) Kirchner, Beiträge zur Biologie der Bluthen. Progr. z. 72 Jahresfeier d. K. Würtemb. landwirthschaftl. Akademie Hohenheim 51. 1890.—(18)

Kerner, Pflanzenleben. 2: 1891. *L. purpureo-coeruleum*, color change, 190. *L. arvense*, autogamy, etc., 309, 330.—(19) Loew, Blüthenbiologische Beiträge II. Pringsheim's Jahrbücher, **23**: 52–3. 1892. *L. purpureo-coeruleum.*—(20) Mac Leod, Over de bevruchting der bloemen in het Kempisch gedeelte van Vlaanderen. Bot. Jaarboek 5: 335. 1893. *L. arvense.*—(21) Loew, Blütenbiologische Floristik 282. 1894. *L. arvense, purpureo-coeruleum.*

PHYSALIS LANCEOLATA Michx.—According to Kirchner (2) *P. alkekengi* is proterogynous. The anthers finally approach the stigma until autogamy may occur. Kerner (3) states that autogamy results from the lengthening of the corolla.

Physalis lanceolata is common. The stem rises 3^{dm} or more and bears numerous pendulous flowers, which expand about 20^{mm}. The flowers are yellowish, the centers usually marked with five dark purple spots. The nectar is lodged in grooves alternating with the filaments, each groove being bounded on each side by a line of dense hairs. To reach the nectar, bees thrust their proboscides between the bases of the filaments. The broad bases of the filaments with the alternating tufts of hair nearly close the tube. The tufts aid in concealing the nectar and probably aid the bees in clinging to the pendulous flower.

The anthers dehisce in succession, so that to collect all of the pollen, the bees must visit each flower several times. Cross-pollination results from the stigma being in advance of the anthers and being touched before them. There may be slight proterogyny and in absence of insects autogamy may occur as in *P. alkekengi*. *P. lanceolata* blooms from May 12th to Sept. 21st. It is visited regularly and abundantly by (1) *Colletes latitarsis* Rob. ♂♀, s. and c. p., July 6th, Aug. 7th, Sept. 5th, 21st; (2) *C. willistonii* Rob. ♂♀, s. and c. p. May 29th, June 7th, 11th, Sept. 5th.

PHYSALIS VIRGINIANA Mill.—This species resembles the preceding. It blooms from June 7th to Oct. 4th and is visited for nectar and pollen by *Colletes latitarsis* Rob. ♂♀, ab., July 6th, 9th, 22nd, 25th, 26th, and *Halictus pectinatus* Rob. ♀, c. p., two, June 25th.

PHYSALIS PHILADELPHICA Lam.—This also agrees with *P. lanceolata* in most essential particulars. It was noted in bloom from July 12th to Sept. 27th. The flowers are visited for pollen by *Colletes latitarsis* Rob. ♀, July 27th.

The species of *Physalis* occurring in my neighborhood are

remarkable for their close mutual relation with two bees of the genus *Colletes*. As far as known, *Heuchera hispida*[7] is the only other flower adapted to a bee of this genus. On twelve days, between May 29th and Sept. 21st, I found the flowers to be visited by these bees and by no other insects, except the *Halictus* taken on *P. Virginiana*.

I have taken single females of *Colletes latitarsis* on flowers of *Asclepias incarnata* (entrapped and dead) and *Polygonum hydropiperoides*. Both sexes are abundant on *Physalis*, and the female seems to depend exclusively upon the pollen of these flowers.

I have taken *Colletes willistonii* on flowers of *Rhus glabra* and *Melilotus alba*, but have never seen it collecting any pollen except of *Physalis*.

On the pollination of Physalis see:

(1) Sprengel, Das entdeckte Geheimniss 127–8. 1793. *P. alkekengi, pubescens*, nectar-glands, guides, etc.—(2) Kirchner, Neue Beobachtungen über die Bestäubungseinrichtungen einheimischer Pflanzen, Progr. d. 68 Jahresfeier d. K. Würtemb. landwirtsch. Akademie Hohenheim. 1886.—(3) Kerner, Pflanzenleben. **2**: 1891. Protection of pollen, 118, "revolverblüthen," 250, autogamy, 361.—(4) Wettstein, Solanaceæ. Engler u. Prantl, die nat. Pflanzenfamilien 65: 8. 1891. *P.*, pollination of.—(5) Loew, Blütenbiologische Floristik 285. 1894. *P. alkekengi*, ref. (2 and 3).

MIMULUS RINGENS L.—The flowers of *Mimulus* are homogamous. Bees entering the corolla first touch the stigma, which closes up and exposes the anthers behind it. Self-pollination occurs in *M. luteus*, but Darwin (13) found that pollen from another plant was prepotent over the flower's own pollen. He saw *M. roseus* visited by bees. According to Batalin (6) *M. guttatus* is visited by bees.

The irritability of the stigma of *Mimulus* was well known to Kurt Sprengel (1), Braconnot (2) and Vaucher (3). The latter mentions it as occurring in *M. luteus* and *glutinosus*, and supposes that it occurs in other members of the genus. This has been verified to such an extent that now it seems that a *Mimulus* without an irritable stigma would be a desideratum. Delpino (4, 7) was first to indicate the advantage of the movement in facilitating cross-pollination.

In the case of *Mimulus ringens*, Meehan (17) states that the stamens dehisce and the stigmas generally show pollen before the flowers are quite open. He observes the movement of

[7] Bot. Gaz. **17**: 178. 1892.

the stigma, and is the only one who does not regard it of any advantage. According to Beal (18) a student, Penoyer, has proved by detailed experiment that the flower is not self-pollinating. Foerste (25) observes that cross-pollination is not insured, and that the tubes are too long for the smaller bees.

The flowers are violet purple, the yellow palate forming a path-finder. The stigma slightly exceeds the anthers. I have found the lower lobe of the stigma with its tip touching the pollen. But most of the stigmatic surface remains exposed and may be thoroughly dusted with pollen from another flower. The corolla tube measures about 19^{mm}, but bees can insert their heads for about 5^{mm}, so that a tongue 14^{mm} long can exhaust the nectar. The plants are frequent in wet places, the stems growing from 11 to 14^{dm} high. The flowers were observed in bloom from July 11th to September 7th. They are visited for nectar by *Bombus americanorum* F. ♀☿.

MIMULUS ALATUS Soland.—See Foerste (25).—This flower is also adapted to bumblebees. It resembles the preceding, but the palate is larger, paler, and more strongly bearded. The tube measures 18^{mm} long. Bees can insert their heads for about 7^{mm} and drain the tube with a proboscis 11^{mm} long. As in *M. ringens*, the stigma finally touches the pollen and may be self-pollinated, but I am inclined to believe that the flowers are seldom neglected for a whole day, and are regularly cross-pollinated by bumblebees. The plants are not so tall as in *M. ringens*. They bloom from July 13th to Sept. 7th. The flower is visited for nectar by *Bombus americanorum* F.☿.

On the pollination of Mimulus see:

(1) Sprengel, Anleitung zur Kenntniss der Gewächse **1**: 192, 274. 1817.—(2) Braconnot, Sur l'irritabilité du stigmate des Mimulus. Ann. de Chim. et de Phys. **29**: 333–4. 1825.—(3) Vaucher, Histoire physiologique des Plantes d' Europe **3**: 525. 1841.—(4) Delpino, Sugli apparecchi della fecondazione nelle piante antocarpee 32. 1867.—(5) Hildebrand, Federigo Delpino's Beobachtungen über die Bestäubungseinrichtungen bei den Pflanzen. Bot. Zeit. **25**: 284. 1867. *M. glutinosus* (*Diplacus puniceus* Nutt.), irritable stigma.—(6) Batalin, Beobachtungen über die Bestäubung einiger Pflanzen. Bot. Zeit. **28**: 53–4. 1870. Sensitive stigma, etc.—(7) Delpino, Ulteriori osservazioni. II. 2: 151. 1873.—(8) Müller, Befruchtung der Blumen 283. 1873.—(9) Kitchener, On cross-fertilization as aided by sensitive motion in musk and Achimenes. Jour. of Bot. **2**: 101–3. Am. Nat. **7**: 478–80. 1873. *M. moschatus*.—(10) Kitchener, A Year's Botany 118. 1874. Significance of sensitive stigma. Cit. by Darwin (13).—(11) Heckel, Du mouvement dans les stigmates bilobiés des Scrophularinées, des Bignoniacées et des Sésamées. Comptes Rendus **79**: 702–4. 1874. Cit. by

Miyoshi (28).—(12) Heckel, Sur la motilite dans quelques organes reproducteurs des Phanerogames. Thèse pour le doctorat ès sci. naturelles. 1875.—(13) Darwin, Cross and self-fertilization of plants. 1876. *M. roseus*, irritable stigma and visitors, 63. *M. luteus*, extended observations.—(14) Henslow, On the self-fertilization of plants. Trans. Linn. Soc. II. **1**:—1877. *M. luteus*, review of Darwin's observations.—(15) Behrens, Beiträge zur Geschichte der Bestäubungstheorie. Progr. d. Kgl. Gewerbschule zu Elberfeld 24–5. 1877–8. *M. luteus* (*Tilingii*), sensitive stigma, homogamy, etc.—(16) Heckel, Des relations que presentent les phénomènes propres aux organes reproducteurs de quelques Phanérogames avec la fécondation croisée et la fécondation directe. Comptes Rendus **87**: 697–700. 1878. Sensitive stigmas and pollination.—(17) Meehan, Irritable or sensitive stamens. Proc. Acad. Sci. Phila. **1878**: 333.—(18) Beal, The agency of insects in fertilization. Am. Nat. **14**: 202. 1880.—(19) Behrens, Blumen und Insekten. Methodisches Lehrbuch der Botanik für hohere Lehranstalten. 1880. *M. luteus* (*Tilingii*).—(20) Thompson, Fertilization of New Zealand flowering plants. Trans. New Zeal. Institute **13**: 241–88. 1880. *M. luteus*.—(21) Meehan, The stigma of Catalpa. Bot. Gaz. **8**: 191. 1883. Stigma of common garden *M.* closes in fifteen seconds.—(22) Müller, Fertilization of Flowers 436. 1883. *M. luteus* (*guttatus*, *Tilingii*), *puniceus*, ref. (5, 6, 15)—(23) Hoffmann, Culturversuche über Variation. Bot. Zeit. **42**: 216. 1884. *M. cardinalis* × *moschatus*, fruitful.—(24) Oliver, Ueber Fortleitung des Reizes bei reizbaren Narben. Ber. deut. bot. Gesellsch. **5**: 162–9. 1887. *M. luteus*, *cardinalis*.—(25) Foerste, Notes on structures adapted to cross-fertilization. Bot. Gaz. **13**: 153. 1888. *M. alatus*, *ringens*.—(26) Hansgirg, Ueber die Verbreitung der reizbaren Staubfäden und Narben, etc. Bot. Centralblatt **43**: 413. 1890. *M. ringens*, *purpureus*, *Lewissii*, *Californicus*, *parviflorus*, *moschatus*, *cardinalis*, *luteus*, (*Roezlii*, *cupreus*, *guttatus*, *Tilingii*).—(27) Kerner, Pflanzenleben **2**: 127, 253, 280. *M. luteus*.—(28) Miyoshi, Notes on the irritability of the stigma. Journ. of Sci. Imp. Univ. Tokio **1891**: 211. *M. Nepalensis*, *sessilifolius*, *moschatus*.—(29) Wettstein, Scrophulariaceæ. Engler und Prantl, Die nat. Pflanzenfamilien 65: 46–7. 1891. Pollination.

Carlinville, Illinois.

[FROM THE BOTANICAL GAZETTE, VOL. XXI.]

Flowers and insects. XV.[1]

CHARLES ROBERTSON.

POLYGONUM Tourn.—For the present I withhold the consideration of the mode of pollination and of the copious special literature and contribute lists of insect visitors of the two following species.

POLYGONUM PENNSYLVANICUM L.—The visitors observed on nine days between Aug. 8th and Sept. 16th, are as follows:

HYMENOPTERA—*Apidæ:* (1) Apis mellifica L. ☿, ab.; (2) Bombus separatus Cr. ♂; (3) B. americanorum F. ♂☿; (4) B. virginicus Oliv. ♂☿, ab.; (5) Megachile brevis Say ♂; *Andrenidæ:* (6) Andrena asteris Rob. ♂; (7) Agapostemon radiatus Say ♂; (8) Augochlora viridula Sm. ♀; (9) A. pura Say ♀; (10) Halictus fasciatus Nyl. ♀; (11) H. pilosus Sm. ♀; (12) H. confusus Sm. ♀; (13) H. stultus Cr. ♀; *Vespidæ:* (14) Polistes pallipes Lep.; (15) P. rubiginosus Lep.; (16) P. metricus Say; (17) P. annularis L.; *Eumenidæ:* (18) Odynerus tigris Sauss., freq.; (19) O. capra Sauss., freq.; *Crabronidæ:* (20) Crabro interruptus Lep.; (21) C. 6-maculatus Say; *Philanthidæ:* (22) Cerceris clypeata Dlb.; *Larridæ:* (23) Ancistromma distincta Sm.; *Sphecidæ:* (24) Ammophila intercepta Lep.; (25) Chlorion caeruleum Dru.; (26) Priononyx atrata Lep.; *Pompilidæ:* (27) Pompilus philadelphicus Lep.; (28) Priocnemis fulvicornis Cr.; (29) Planiceps niger Cr.; *Scoliidæ:* (30) Myzine sexcincta F.—all sucking.

DIPTERA—*Bombylidæ:* (31) Sparnopolius fulvus Wd.; *Syrphidæ:* (32) Syrphus ribesii L.; (33) S. americanus Wd., freq.; (34) Mesograpta polita Say; (35) M. marginata Say; (36) Eristalis tenax L.; (37) E. aeneus F.; (38) Tropidia quadrata Say; (39) Syritta pipiens L.; *Tachinidæ:* (40) Cistogaster immaculata Mcq.; (41) Jurinia smaragdina Mcq., ab.; (42) J. apicifera Wlk.; (43) Micropalpus fulgens Mg.; (44) Frontina acroglossoides Twns.; (45) F. flavicauda Riley; (46) Atrophopoda singularis Twns.; *Sarcophagidæ:* (47, 48) Sarcophaga spp.; *Muscidæ:* (49) Graphomyia sp., freq.; (50) Lucilia caesar L.; (51) L. cornicina F.; (52) Compsomyia macellaria F.—all sucking.

LEPIDOPTERA —*Rhopalocera:* (53) Pieris protodice B.-L.; (54) P. rapæ L.; (55) Colias philodice Gdt.; (56) Chrysophanus thoe B.-L.; (57) Pamphila cernes B.-L.; *Heterocera:* (58) Heliothis armiger Hüb.; (59) Scepsis fulvicollis Hüb.—all sucking.

COLEOPTERA —*Lampyridæ:* (60) Chauliognathus pennsylvanicus DeG., s., ab.

POLYGONUM HYDROPIPEROIDES Michx.—The following visitors were observed Aug. 30th and Sept. 20th:

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[1] Contributions to an account of the ecological relations of the entomophilous flora and the anthophilous insect fauna of the neighborhood of Carlinville, Illinois.

HYMENOPTERA—*Apidæ:* (1) Apis mellifica L., ☿; (2) Ceratina dupla Say ♀; (3) Megachile brevis Say ♂; (4) M. mendica Cr. ♀; *Andrenidæ:* (5) Andrena solidaginis Rob. ♀; (6) Agapostemon radiatus Say ♂ ♀; (7) Halictus coriaceus Sm. ♂, freq.; (8) H. lerouxii Lep. ♀; (9) H. fasciatus Nyl. ♀; (10) Colletes armata Pttn. ♂; (11) C. eulophi Rob. ♂; (12) C. americana Cr. ♂ ♀, freq.; (13) C. latitarsis Rob. ♀; (14) Prosopis pygmaea Cr. ♂; *Vespidæ:* (15) Polistes pallipes Lep.; (16) P. metricus Say; *Eumenidæ:* (17) Odynerus capra Sauss.; (18) O. dorsalis F.; (19) O. arvensis Sauss.; *Crabronidæ:* (20) Crabro texanus Cr.; (21) C. trifasciatus Say; (22) Thyreopus tumidus Pack.; (23) Anacrabro ocellatus Pack.; (24) Oxybelus 4-notatus Say; (25) O. emarginatus Say; *Philanthidæ:* (26) Philanthus ventilabris F.; (27) P. punctatus Say; (28) Eucerceris zonatus Say: (29) Cerceris fumipennis Say; (30) C. kennicottii Cr.; *Nyssonidæ*: (31) Gorytes phaleratus Say; *Larridæ:* (32) Astata bicolor Say; (33) Ancistromma distincta Sm.; (34) Tachytes aurulentus F.; *Sphecidæ:* (35) Pelopoeus cementarius Dru.; (36) Isodontia philadelphica Lep.; (37) Sphex ichneumonea L.; (38) Prionony x thomæ F.; (39) P. atrata Lep.; *Pompilidæ:* (40) Pompilus philadelphicus Lep.; (41) P. algidus Sm.; (42) P. biguttatus F.; (43) P. navus Cr.; (44) Ceropales fraterna Sm.; *Scoliidæ:* (45) Tiphia tarda Say; (46) Myzine sexcincta F.; *Mutillidæ:* (47) Sphaerophthalma macra Cr.; *Chrysididæ:* (48) Holopyga ventralis Say; (49) Hedychrum wiltii Cr.; (50) H. violaceum Brullé; (51) Chrysis texana Grib.; (52) C. nitidula F.

DIPTERA—*Bombylidæ:* (53) Systoechus vulgaris Lw.; *Conopidæ:* (54) Conops brachyrrhynchus Mcq.; *Syrphidæ:* (55) Paragus tibialis Fll.; (56) Eristalis bastardi Mcq.; (57) E. flavipes Wlk.; (58) Tropidia quadrata Say; (59) Syritta pipiens L.; *Tachinidæ:* (60) Jurinia apicifera Wlk.: (61) Frontina acroglossoides Twns.; *Sarcophagidæ:* (62–64) Sarcophaga spp.; *Muscidæ:* (65) Lucilia caesar L.; (66) L. cornicina F.; (67) Compsomyia macellaria F.; *Anthomyidæ:* (68) Coenosia sp.

COLEOPTERA—*Coccinellidæ:* (69) Coccinella 9-notata Hbst.; *Lampyridæ:* (70) Chauliognathus pennsylvanicus DeG.; *Chrysomelidæ:* (71) Disonycha limbicollis Lec. v. pallipès Cr.; *Curculionidæ:* (72) Listronotus caudatus Say.

DIRCA PALUSTRIS L.—This is a low shrub blooming quite early, March 18th to April 13th, and bearing small greenish yellow flowers which appear before the leaves. At the ends of the branchlets are situated buds of about four hairy scales enclosing, in cases observed by me, three flower-buds and a leaf-bud. The flowers are pendulous and are sheltered by the bud scales which form a hood above them.

The calyx tube is about 5^{mm} long and is truncate, with obscure lobes. The bottom of the tube is completely filled by the ovary so that with a proboscis 4^{mm} long a bee may obtain all the nectar, which I think is secreted by the tube. For the distance of about 1^{mm} from the ovary to the point where the stamens are inserted the tube is narrow. Above that point it is wider but is obstructed by the eight filaments and the

style. The anthers are exserted about 2^{mm} beyond the mouth of the tube, the alternate ones being somewhat shorter. The stigma is advanced about 2^{mm} further.

In a bud which had just begun to open I found that the flowers had the anthers reaching just to the mouth, but the stigmas advanced 2^{mm} beyond. The anthers were closed but the stigmas were receptive. There was thus an appearance of proterogyny, but it must be short-lived, for all of the other flowers which I observed had the anthers dehiscent, the larger ones, however, shedding their pollen first. The arrangement for cross-pollination is the simple one, common in pendulous flowers, of the stigma being in advance of the anthers. Pollination between flowers of the same plant may occur, but I think there is little chance of self-pollination.

As noted above, the calyx has obscure lobes, and my examination of early cases, in which the open mouths of the tubes were crowded with the swollen anthers, leads me to believe that the abortion of the lobes is correlated with the fact that the young flowers are protected by the scales which form the common envelope of the leaf-bud and the flower cluster.

The pendulous position of the flowers, the comparatively deep, narrow tube, and the early blooming time convince me that the flowers are adapted to the smaller bees. The following list of visitors, observed March 21st, confirms this view:

HYMENOPTERA—*Apidæ:* (1) Ceratina dupla Say ♂; (2) C. tejonensis Cr. ♂: (3) Osmia lignaria Say ♂; (4) Nomada maculata Cr. ♂; *Andrenidæ:* (5) Halictus sp. ♀; (6) H. zephyrus Sm. ♀; (7) H. confusus Sm. ♀; (8) Augochlora labrosa Say ♀; (9) Andrena rugosa Rob. ♂; (10) Colletes inaequalis Say ♂—all s.

LEPIDOPTERA—*Nymphalidæ:* (11) Vanessa antiopa L., s.

EUPHORBIA L.—As in the case of *Polygonum*, I omit remarks upon the mode of pollination and references to the literature.

EUPHORBIA COROLLATA L.—The stems grow from 6 to 10^{dm} high and are terminated by large umbel-like clusters with white involucres which make it the most conspicuous of our Euphorbias.

It was observed in bloom from May 24th to Sept. 27th. The following list, consisting mainly of flies, on which the plant seems to depend, with the exception of no. 1, was observed on July 25th:

DIPTERA—*Bombylidæ:* (1) Anthrax alternata Say; *Syrhpidæ:* (2) Paragus tibialis Fll.; (3) P. bicolor F.; (4) Pipiza pulchella Will.; (5) Chrysogaster nitida Wd.; (6) Allograpta obliqua Say; (7) Spaerophoria cylindrica Say; (8) Syritta pipiens L.; *Tachinidæ:* (9) Cistogaster immaculata Mcq.; (10) Miltogramma argentifrons Twns.; *Muscidæ:* (11) Lucilia cornicina F.; (12) Cyrtoneura sp.

HYMENOPTERA—*Andrenidæ:* (13) Prosopsis pygmaea Cr. ♀; *Pompilidæ*: (14)Pompilus relativus Fox.—all sucking.

HEMIPTERA--*Coreidæ:* (15) Chariesterus antennator F., s.

SALIX Tourn.—The flowers of willows are dioecious and entomophilous, but Warming (21) regards *S. herbacea* and some other species as anemophilous in Greenland. In the Alps, according to Müller (15), *S. herbacea* secretes abundant nectar and is visited by insects. Kerner (24) observed some species to be proterogynous, with the result that at first they could only receive pollen from flowers of other species and consequently produced hybrids.

Sprengel (1) regarded the staminate catkins as being more conspicuous than the pistillate in order that the latter might thus be more likely to be visited by insects which had first become dusted with pollen from the staminate flowers. While it is a fact that the staminate catkins are more attractive to insects, and, in spite of Bonnier's (11) statements to the contrary, are more abundantly visited by them, it can hardly be maintained that the increased conspicuousness was developed on this account, for, as claimed by MacLeod (27), the staminate flowers of anemophilous plants are also more conspicuous than the others. I have often noticed that the catkins of *Populus monilifera* were quite red or yellow, making them more brightly colored than in any of our species of *Salix*.

From their readily accessible nectar and exposed pollen, the catkins are especially attractive to the less specialized bees (*Andrenidæ*) and to the flower flies (*Syrphidæ*) and in most of the cases given in the table these are the most abundant guests, together forming a majority of all the visitors. Except for the services of these insects there seems to be little reason why the flowers should bloom early, for all of the other insect groups, except the *Empidæ*, have more species later in the season. I suspect that, whenever a satisfactory list of visitors of a willow is made out, it will show a preponderance of *Andrenidæ* and *Syrphidæ*, unless there is some peculiarity in the insect fauna of the region.

The following table gives the results of observations made

in different regions in cases in which the insects have been identified:

Salix.	Region.	Observer.	Andrenidæ and Syrphidæ.	Other insects.	Other Hymenoptera.	Apidæ.	Andrenidæ.	Syrphidæ.	Other Diptera.	Other insects.
cordata	Illinois ...	....	49	38	7	8	28	21	18	5
humilis	Illinois ...	....	27	24	5	3	20	7	9	7
cinerea ... / caprea .... / aurita	Germany..	Müller (6, 12, 17)..	61	52	9	19	44	17	16	8
cinerea	Germany..	Loew (20)........	1	1	....	1	1	..	....	....
caprea	Germany..	Loew (28)........	11	5	....	4	11	..	1	....
aurita.......	Germany..	Loew (20, 28).....	1	2	....	1	..	1	1	....
nigricans ...	Germany..	Loew (20)........	1	1	....	1	1	..	....	....
alba........	Germany..	Loew (28)........	....	1	....	..	..	..	1	....
amygdalina..	Germany..	Loew (28)........	1	....	....	..	1	..	....	....
amygdalina..	Germany..	Müller (12).......	2	3	....	1	2	..	2	....
fragilis	Germany..	Müller (12).......	2	4	1	1	2	..	....	2
repens	Germany..	Müller (6, 17)	4	6	1	2	4	..	2	1
repens	Norderney	Verhoeff (26)	7	26	2	4	1	6	14	6
Early spp ...	Flanders..	Mac Leod (27)....	15	28	5	6	12	3	15	2
Late spp	Flanders..	Mac Leod (27)....	7	5	....	1	3	4	4	....
herbacea	Alps......	Müller (15, 17)....	....	2	....	..	..	..	1	1
reticulata ...	Alps......	Müller (15).......	....	1	....	..	..	..	....	1
retusa	Alps......	Müller (15).......	....	1	1	..	..	..	....	....

Those species which bloom before the leaves appear—as in the two following cases—are more abundantly visited because they have fewer competitors, and because their flowers are less concealed by the leaves.

Salix cordata Muhl. blooms from March 18th to April 23d. On April 9–11th, 14th, 17th, 18th, and 20th the following insects were taken on the flowers:

Hymenoptera—*Apidæ:* (1) Ceratina dupla Say ♂, s., freq.; (2) Osmia lignaria Say ♂, s.; (3) Nomada sayi Rob. ♂♀, s., very ab.; (4) N. maculata Cr. ♂♀, s.,very ab.; (5) N. luteola Lep. ,♂♀ s., ab.; (6) N. luteoloides Rob. ♂, s.; (7) N. articulata Sm. ♂, s.; (8) N. integra Rob. ♂♀, s., ab.; *Andrenidæ:* (9) Andrena erythrogaster Ashm. ♂♀, s., and c. p., ab., in cop.; (10) A. sayi Rob. ♂♀, s., ab.. in cop.; (11) A. salicis Rob. ♂♀, s. and c. p.; (12) A. illinoensis Rob. ♂♀, s. and c. p., ab., in cop.; (13) A. flavo-clypeata Sm. ♂♀, s., ab., in cop.; (14) A. cressonii Rob. ♂, s., ab.; (15) A. nuda Rob. ♀, s.; (16) A. rugosa Rob. ♂♀, s.; (17) A. erythronii Rob. ♂, s.; (18) A. forbesii Rob. ♀, s.; (19) A. hippotes Rob. ♂, s.; (20) A. mariæ Rob. ♂♀. s. and c. p., ab.: in cop.; (21) A. claytoniæ Rob. ♂♀, s., ab.; (22) A. mandibularis Rob. ♂, s.; (23) A. pruni Rob. ♂; (24) Panurgus? andrenoides

Cr. ♂♀, s., very ab., in cop.; (25) Agapostemon radiatus Say ♀, s.; (26) Augochlora similis Rob. ♀, s.; (27) A. pura Say ♀, s.; (28) Halictus foxii Rob. ♀, s., ab.: (29) H. forbesii Rob. ♀, s., (30) H. lerouxii Lep. ♀, s., freq.; (31) H. pilosus Sm. ♀, s., freq.; (32) H. zephryus Sm. ♀, s.; (33) H. confusus Sm. ♀, s.; (34) H. stultus Cr. ♀, s.; (35) Sphecodes arvensis Pttn. ♀, s.; (36) Colletes inaequalis Say ♂, s.; *Vespidæ:* (37) Polistes rubiginosus Lep., s.; *Pompilidæ:* (38) Priocnemis conicus Say, s.; *Ichneumonidæ:* (39) Pimpla sp.; *Tenthredinidæ:* (40) Nematus vertebratus Say; (41) N. luteotergum Nort.; (42) Dolerus arvensis Say, s., ab.; (43) D. bicolor Bv., s., freq.

DIPTERA—*Simulidæ:* (44) Simulium sp. s.; *Empidæ:* (45) Empis otiosa Coq., s.; (46) Rhamphomyia gilvipilosa Coq., s.; *Conopidæ:* (47) Myopa vesiculosa Say, s.; (48) M. pilosa Will.; *Syrphidæ:* (49) Psilota buccata Mcq.; (50) Chrysogaster pictipennis Will., ab.; (51) Chilosia sp.; (52) Melanostoma obscurum Say; (53) Platychirus hyperboreus Staeg.; (54) P. quadratus Say, freq.; (55) Syrphus ribesii L.; (56) S. americanus Wd., ab.; (57) Sphaerophoria cylindrica Say; (58) Chalcomyia aerea Lw.; (59) Brachyopa vacua O. S.; (60) Eristalis aeneus F., ab.; (61) E. dimidiatus Wd., ab.; (62) E. transversus Wd.; (63) E. flavipes Wlk.: (64) Helophilus similis Mcq., ab.; (65) Tropidia mamillata Lw.; (66) Brachypalpus rileyi Will., ab.; (67) B. frontosus Lw., very ab.; (68) Xylota fraudulosa Lw., ab.; (69) Syritta pipiens L.; *Tachinidæ:* (70) Gonia frontosa Say, ab.; (71) G. exul Will.; *Sarcophagidæ:* (72) Cynomyia sp., ab.; *Muscidæ:* (73) Lucilia cornicina F., ab.; *Anthomyidæ:* (74) Chortophila sp.; *Cordyluridæ:* (75) Scatophaga squalida Mg., ab.; *Sciomyzidæ:* (76) Tetanocera sp.; (77) T. pictipes Lw.; *Lonchaeidæ:* (78) Lonchaea sp.; (79) L. polita Say; *Sepsidæ:* (80) Sepsis sp.; *Oscinidæ:* (81) Oscinis sp.; *M. acalyptratæ:* (82) sp.—all s. or f. p.

COLEOPTERA—*Chrysomelidæ:* (83) Orsodachna atra Ahr., ab.; (84) Lina lapponica L., ab.; (85) Galeruca tuberculata Say, freq.; *Oedemeridæ:* (86) Asclera puncticollis Say, freq.—all s. or f. p.

HEMIPTERA—*Capsidæ:* (87) Lygus pratensis L. s.

SALIX HUMILIS Marsh.—This species was observed in bloom from the 18th of March to the 21st of April. On March 18th and April 6–12th, 14th, 17th, 20th and 21st the following visitors were noted:

HYMENOPTERA—*Apidæ:* (1) Apis mellifica L. ☿, s. and c. p., ab.; (2) Bombus virginicus Oliv. ♀; (3) Ceratina dupla Say ♂, freq.; *Andrenidæ:* (4) Andrena vicina Sm. ♂♀, ab.; (5) A. erythrogaster Ashm ♂; (6) A. salicis Rob. ♂♀, s., freq.; (7) A. illinoensis Rob. ♂; (8) A. erythronii Rob. ♂♀; (9) A. cressonii Rob. ♂; (10) A. flavo-clypeata Sm. ♂; (11) A. rugosa Rob. ♂; (12) A. forbesii Rob. ♀; (13) Agapostemon radiatus Say ♀; (14) Augochlora pura Say ♀; (15) Halictus arcuatus Rob. ♀; (16) H. forbesii Rob. ♀; (17) H. coriaceus Sm. ♀; (18) H. lerouxii Lep. ♀, ab.; (19) H. fasciatus Nyl. ♀; (20) H. confusus Sm. ♀; (21) H. pruinosus Rob. ♀; (22) Sphecodes arvensis Pttn. ♀; (23) Colletes inaequalis Say ♂♀, ab.; *Ichneumonidæ:* (24) Ichneumon funestus Cr.; (25) Colpognathus helvus Cr.: *Tenthredinidæ:* (26) Dolerus arvensis Say, ab.; (27) D. bicolor Br., ab.; (28) D. sericeus Say—all s.

DIPTERA—*Syrphidæ:* (29) Syrphus americanus Wd.; (30) Sphaerophoria cylindrica Say; (31) Eristalis aeneus F.; (32) E. dimidiatus Wd.,

ab.; (33) E. latifrons Lw.; (34) Helophilus similis Mcq., ab.; (35) Brachypalpus frontosus Lw., ab., *Tachinidæ:* (36) Gonia frontosa Say, ab.; *Sarcophagidæ:* (37) Cynomyia sp., ab.; *Muscidæ:* (38) Lucilia caesar L.; (39) Lucilia cornicina F., ab.; *Anthomyidæ:* (40–41) Chortophila spp.; (42) Hyetodosia 4-notata Mg.; *Cordyluridæ:* (43) Scatophaga squalida Mg., ab.; *Sepsidæ:* (44) Sepsis sp., ab.—all s.

COLEOPTERA—*Coccinellidæ:* (45) Hippodamia parenthesis Say; *Lampyridæ:* (46) Ellychnia corrusca L.; *Chyrsomelidæ:* (47) Orsodachna atra Ahr., ab.—all s.

HEMIPTERA—*Lygaeidæ:* (48) Lygaeus turcicus F.; *Pentatomidæ:* (49) Euschistus variolaris P. B. (det. by Uhler); *Capsidæ:* (50) Lygus pratensis L.—all s.

LEPIDOPTERA—*Rhopalocera:* (51) Vanessa antiopa L., s.

The staminate flowers are so thoroughly monopolized by hive-bees that other insects are almost entirely absent. Accordingly, most of the insects in the list were taken on the pistillate flowers which they visited only for nectar.

On the literature of *Salix* see:

(1) Sprengel, Das entdeckte Geheimniss 31. 437–8. 1793. *S. caprea* visitors, etc.—(2) Hildebrand, Geschlechter-vertheilung bei den Pflanzen 9. 12. 1867. Diclinism.—(3) Axell, Om anordningarna för de fanerogama växternas befruktning 47, 62, 93, 113. 1869. *S. pentandra, cinerea, nigricans.*—(4) White, Winter fertilization by agency of insects. Journ. Bot. N. S. **1**: 48, F 1872. Visitors of ♂ and ♀ fls.—(5) Delpino, Ulteriori osservazioni Pt. II. fasc. 2: (154). 1875. Atti d. Soc. Ital. d. Sci. Nat. in Milano. **16**: 302. 1873. Lit. (1) and (4).—(6) Müller, Befruchtung der Blumen 149–50. 1873.—(7) Kerner, Die Schutzmittel des Pollens 50. 1873.—(8) Kerner, Die Schutzmittel der Blüthen gegen unberufene Gäste. 1876. *S. daphnoides,* Wachsüberzüge. (Just Bot. Jahresbericht **4**: 942).—(9) Meehan, On self-fertilization and cross-fertilization of flowers. Penn Monthly. N 1876. *S. caprea.* Sep. pamphlet 1877. (Just **4**: 939).—(10) H. H., Fertilization of Salix repens. Nature **16**: 184. 1877. Visitors. (Just **5**: 746). — (11) Bonnier, Les Nectaires. Ann. d. Sci. Nat. Bot. **8**: 39, 49–50, 57, 70–1. 1879. Several spp., visitors, etc. — (12) Müller, Weitere Beobachtungen. II. Verh. d. naturhist. Ver. d. preuss. Rheinl. u. Westf. **1879**: 210.—(13) Behrens, Biologische Fragmente. Jahresbericht d. Naturw. Gesellschaft zu Elberfeld. 1880. *S. repens.*—(14) Delpino, Proporzione delle piante anemofile ed entomofile nelle isole. Revista Botanica **1880**: 50–2. Lit. (13) (Just **8**[1]: 190).—(15) Müller, Alpenblumen 162–3. 1881. —(16) Mez, Geschlechtsänderung einer Weide. Deutsch. bot. Monatschr. **1**: 93. 1883. *S. purpurea × viminalis.* (Just **11**[1]: 483)—(17) Müller, Fertilization of Flowers 524–6. 1883.—(18) Heinricher, Beiträge zur Pflanzenteratologie und Blütenmorphologie. Sitzber. d. K. Akad. d. Wissensch. Wien **87**: 1883. *S. caprea,* androgynous catkins. (Just **11**[1]: 483).—(19) Müller, Die Stellung der Honigbiene in den Blumenwelt III. Deut. Bienenzeit. **39**: 157–61. 1883. (Just **11**[1]: 476).—(20) Loew, Beobachtungen über den Blumenbesuch von Insekten an Freilandpflanzen des botanischen Gartens zu Berlin. Jahrb. bot. Gartens Berlin **3**: 82, 274, 276. (14, 72, 74). 1884.—(21) Warming, Om bygningen og den formodede bestövningsmaade af nogle grönlandske blom-

ster. Oversigt over d. K. D. Vidensk. Selsk. Forhandl. 1886: 116, 131, 156.—(22) Pax, Salicaceæ. Engler u. Prantl. Die nat. Pflanzenfamilien. 14: 33. 1887. (Just 16[1]: 563).—(23) Bulman, The bee and the willow. Sci. Gossip 1889: 130.—(24) Kerner, Die Bedeutung der Dichogamie. Oest. bot. Zeitschrift 40: 2–3. 1890.—(25) Kerner, Pflanzenleben 2: 187, 311–12. 1891. Several spp. (Just 17[1]: 532).—(26) Verhoeff, Blumen und Insekten der Insel Norderney. Nova Acta d. Kais. Leop. Carol. Deutsch. Akad. d. Naturf. 61: 63–8. 1893.—(27) MacLeod, Over de bevruchting der bloemen in het Kempisch gedeelte van Vlaanderen. Bot. Jaarboek 6: 129–33, etc. 1894. —(28) Loew, Blütenbiologische Floristik des mittleren und nördlichen Europa sowie Grönlands. 1894. (11 spp).—(29) Knuth, Blumen und Insekten auf den Nordfriesischen Inseln 131–2. 1894. *S. repens.*—(30) Weed, Ten New England blossoms and their insect visitors. 1–17. 1895. *S. discolor*, visitors, etc.

IRIS Tourn.—In this genus we find regular trilateral nototribe flowers. Each sepal, with a stamen and a style-division, is modified into a form which is almost a functional equivalent of a specialized flower such as we find in the Scrophulariaceæ, etc. The form of the style serves to determine the kind of insect pollinators and secures the application of the pollen to the insect's back. Kerner (5,23) mentions the style of *Iris* as serving to protect the pollen, without, however, showing the probability of this having anything to do with its development.

Except in the single case mentioned below, the flowers are adapted to bumblebees, but are also visited by other large bees, such as *Xylocopa* (Delpino 6), and in this country by *Synhalonia*. *I. pseudacorus* (Müller 4) presents an interesting case of what Errera and Gevaert (11) call *dientomophily*—having one form adapted to bumblebees and another adapted to *Rhingia rostrata*, a Syrphid fly. The only other case as yet recorded is that of *Aconitum lycoctonum*, observed by Aurivillius (see Ludwig 19, 25), which has one form visited by bumblebees and another visited by butterflies. Gibson (28) in an account of the blue-flag, accompanied by a figure evidently of *I. versicolor*, implies that *Iris* in general is adapted to bumblebees and large flies. "A large fly" is a rather loose synonym for *Rhingia rostrata*.

Iris has sometimes been used as a type of hercogamy (ercogame contingentẹ, Delpino 6), but *I. sibirica* has been shown to be proterandrous (Dodel Port 24, Loew 30). It will be seen below that *I. versicolor* is also proterandrous to some extent. Meehan (9) records a case in which *I. virginica* is said to have proved fertile under a net.

IRIS VERSICOLOR L. Larger blue flag.—This flower is described by Professor Goodale in "Wild Flowers of America," 32-35, and is there illustrated by a drawing by Isaac Sprague.

Newly opened flowers show the anthers dehiscent, but the stigmatic lobe is so closely appressed to the summit of the style that the true stigma is not touched by a bee entering the flower. Then in the early stages the tip of the anther lies against the stigma lobe and prevents its being reflexed. Later the style lengthens and the lobe loosens so that the true stigma may be touched. From the above it will be seen that the flower shows a tendency to proterandry.

The flower is adapted to long-tongued bees I have seen it visited by *Bombus americanorum* F. ♀, *B. pennsylvanicus* DeG. ♀, and *Synhalonia frater* Cr. ♂♀, ab. I have also seen a beetle, *Trichius piger* F., enter the flower so as to effect pollination, but this insect cannot reach the nectar. Sometimes butterflies obtain the nectar in an illegitimate way by backing down to the base of the flower and inserting their proboscides between the bases of the "falls" and the style divisions. *Chrysophanus thoe* B.-L. and *Pamphila peckius* Kby. were observed stealing the nectar in this way.

The flowers bloom from May 20th to June 14th.

In New Hampshire, Weed (31) saw the flowers visited by bumble-bees, of which the most abundant species was *Bombus terricola*, and occasionally by some smaller bees. A more frequent visitor was "a good-sized syrphid fly—apparently a species of Rhingia." Several species of skippers (Hesperidæ) and Sphingidæ stole the nectar from the outside, as described above, *Hemaris thysbe* sometimes sucking in the legitmate way.

On the pollination of *Iris* see:

(1) Sprengel, Das entdeckte Geheimniss. 20, 43-4, 69-79. 1793. *I. pseudacorus, xiphium, germanica, sibirica.*—(2) Hildebrand, Geschlechtervertheilung bei den Pflanzen 59. 1867.—(3) Axell, On anordningarna för de fanerogama växternas befruktning 114. 1869. *I. pseudacorus*—(4) Müller, Befruchung der Blumen 67-70. 1873. Fertilization of Flowers 543-7. 1883. *I. pseudacorus.*—(5) Kerner, Schutzmittel des Pollens 12. 1873.—(6) Delpino, Ulteriori osservazioni Pt. II. fasc. 2. Atti d. Soc. Ital. d. Sci. Nat. in Milano. 16: 196, 201, 217, 220, 235, 263, 282, 340. (48, 53, 69. 72. 87, 115, 134. 192) 1873. 17:—(203-4, 247). 1874. *I. aphylla, viscaria, germanica, xiphium, halofila, graminea, florentina, pseudacorus.*—(7) Gray, Botany for young people. II. How plants behave 21, 25. 1875.—(8) Lubbock, British wild flowers in relation to insects 176. 1875. *I. pseudacorus.*—(9) Meehan, On self-fertilization and

cross-fertilization of flowers. Penn Monthly, N 1876. Sep. pamphlet (4). 1877.—(10) Delpino, Dicogamia ed omogamia nelle piante. Nuovo Giorn. Bot. Ital. **8**: 143. 1876.—(11) Errera et Gevaert, Sur la structure et les modes de fecondation des fleurs. Bull. Soc. bot. de Belgique **17**: 149. 1878. (Just Bot. Jahresbericht 6^1: 310)—(12) Hildebrand, Die Farben der Blüthen in ihre jetzigen Variation und früheren Entwickelung 36. 1879. (Just 7^1: 110)—(13) Dodel-Port, Die Liebe der Blumen. 4. 5: 185–240. 1880. (Just 8^1: 183)—(14) Gray, Structural Botany, 230. 1880. *I. pumila.*—(15) Focke, Nägeli's Einwände gegen die Blumentheorie, erläutert an den Nachtfalterblumen. Kosmos **14**: 295. 1884. Just 12^1: 668)—(16) Leow, Beobachtungen über den Blumenbesuch von Insekten an Freilandpflanzen. Jahrb. Bot. Gartens Berlin **3**: 84, 96 (16. 28) 1884. *I. xiphioides, germanica, sibirica.*—(17) Licopoli, Sull polline dell' Iris tuberosa ed altre piante. Rendic. Accad. Sci. Fis. e Mat. Napoli **24**:—1885. [No. 8.]—(18) Licopoli, Le pollen de l' Iris tuberosa. Journ. de micrographie **1886**: No. 2.—(19) Ludwig, Ein neuer Fall verschiedener Blütenformen bei Pflanzen der nämlichen Art, und ein neues Kriterium der Schmetterlings-und Hummelblumen. Biol. Centralblatt **6**: 24. 1887. (Just 15^1: 426)—(20) Licopoli, Sull polline dell' Iris tuberosa. Atti d. r. Acad. d. Sci. Fis. e Mat. II. **2**:— 1888—(21) Pax, Iridaceæ, Engler und Prantl, Die nat. Pflanzenfamilien 10 u. 17: 140–1. 1888. (Just 16^1: 554)—(22) Loew, Beiträge zur blütenbiologischen Statistik. Verh. Bot. Ver. Prov. Brandenburg **31**: 43. 1890. *I. sibirica.*—(23) Kerner, Pflanzenleben **2**: 93, 111, 173, 197, 247. 1891. *I. germanica, odoratissima* etc. (Just 17^1: 528)—(24) Dodel-Port, Zur Kenntniss der Befruchtungserscheinungen bei Iris sibirica. Testsch. z. Feier d. 50 Jahr. Doctorjubiläums der Herren Nägeli u. Kölliker. 1891.—(25) Ludwig, Zur Biologie der. phanerogamischen Süsswasserflora (64) Zacharias, Das Thier- und Pflanzenleben des Süsswassers. 1891.—(26) Mac Leod, De Pyreneeënbloemen en hare bevruchting door insecten 306. 1891. *I. pyrenaica.*—(27) Mac Leod, Over de bevruchting der bloemen in het Kempisch gedeelte van Vlaanderen. Bot. Jaarboek **5**: 168, 315. 1893. *I. pseudacorus.*—(28) Gibson, The welcomes of the flowers. Harper's Monthly **88**: 560. Mr 1894.—(29) Dodel-Port, Biologischer Atlas der Botanik. Serie "Iris." 1894. *I. sibirica*, plates and text. (Knuth Bot. Centralblatt **58**: 95)—(30) Loew, Blütenbiologische Floristik 64–5, 346 391. *I. xiphioides, pseudacorus, sibirica.* 1894.—(31) Weed, Ten New England blossoms and their insect visitors 98–104. 1895.

Carlinville, Illinois.

[From the Botanical Gazette, Vol. XXI.]

Flowers and insects. XVI.[1]

CHARLES ROBERTSON.

Nothoscordum striatum Kunth. *N. ornithogaloides* (Walt.) Kunth.—The plant is common in woods, blooming from April 10th to May 16th. The scapes grow 1 or 2^{dm} high and bear small umbels of white flowers. The flowers are about 10^{mm} long and expand 10 or 12^{mm}. The sepals are approximated below, the base of the tube being greenish and narrowed by the ovary and the filaments of the six stamens. The flowers are homogamous, the stigma occupying the center of the circle of anthers and somewhat surpassing them. Spontaneous self-pollination can hardly occur.

The flower is remarkable for being abundantly visited by numerous species of bees of the genus *Nomada*. On seven days, between April 20th and May 9th, I captured the following visitors:

Hymenoptera—*Apidæ:* (1) Nomada luteoloides Rob. ♂; (2) N. superba Cr. ♂, freq.; (3) N. americana Kby. ♂; (4) N. maculata Cr. ♂♀, ab.; (5) N. cressonii Rob. ♂♀, ab.; (6) N. sayi Rob. ♂♀, freq.; *Andrenidæ:* (7) Augochlora similis Rob. ♀, ab.; (8) Halictus confusus Sm. ♀, s. and c. p.; (9) Andrena sp. ♀, s. and c. p., freq.

Diptera—*Syrphidæ:* (10) Mesograpta marginata Say; (11) Sphaerophoria cylindrica Say, ab.

Lepidoptera—*Rhopalocera:* (12) Colias philodice Gdt.; (13) Pieris rapæ L.; (14) Lycaena comyntas Gdt.; *Heterocera:* (15) Plusia simplex Gn.—All only sucking, except (8) and (9).

Camassia Fraseri (A. Gray) Torr.—The flower is described and figured by Loew (2) from material growing in the Berlin Garden. According to his account, the inflorescence consists of a long loose raceme of twenty or more flowers. The flowers are directed obliquely upwards and have widely expanded sepals. The anther faces are directed forwards so as to touch the visitors, and the stigma is about 4^{mm} in advance of them. Nectar is secreted by septal glands and collects under the base of the ovary.

Loew (1) saw the flowers visited by *Apis mellifica* and *Osmia rufiventris*. He, however, does not consider them to be adapted to these middle-sized bees, but to Lepidoptera, which

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[1] Contributions to an account of the ecological relations of the entomophilous flora and the anthophilous insect fauna of the neighborhood of Carlinville, Illinois.

he supposes may hover in front of the flower in such a way as to come in contact with the anthers and stigma.

The flowers described by him are certainly larger than any I have seen. When watching the flowers being visited by bees and Syrphidæ, it did not occur to me that there was any difficulty in their effecting pollination, though the smallest might obtain the nectar without often touching anthers or stigma. I see nothing about the flower to indicate an adaptation to insects with long tongues or to those of large size.

About Carlinville, the plants are common, sometimes being collected in quite conspicuous patches, which are very attractive to insects. The blooming time is from April 25th to May 16th. The scapes rise from 3 to 6^{dm} high. The flowers are pale blue, or sometimes white. The sepals expand widely, to the extent of two or more cm. The stigma is receptive with, or a little in advance of, the dehiscence of the anthers. The stamens, however, are so strongly divergent that insects may easily touch the stigma before coming in contact with them. The flowers are evidently adapted to bees, but are visited by flies and other insects. On the morning of May 8th, in about an hour, I captured the following visitors:

HYMENOPTERA—*Apidæ:* (1) Apis mellifica L. ☿, s., ab.; (2) Bombus americanorum F. ♀, s., one; (3) Synhalonia frater Cr. ♂♀, s., freq.; (4) S. belfragei Cr. ♂, s.; (5) Ceratina tejonensis Cr. ♂, s.; (6) C. dupla Say ♂, s.; (7) Osmia albiventris Cr. ♂♀, s. & c. p.; (8) Nomada superba Cr. ♂♀, s., freq.; (9) N. americana Kby. ♂, s.; *Andrenidæ:* (10) Halictus pectoralis Sm. ♀, s., freq.; (11) H. forbesii Rob. ♀, s.; (12) H. lerouxii Lep. ♀, s. & c. p.; (13) H. ligatus Say ♀, s. & c. p.; (14) H. fasciatus Nyl. ♀, s. & c. p., ab.; (15) H. pilosus Sm. ♀, s. & c. p., ab.; (16) H. confusus Sm. ♀, s. & c. p., freq.; (17) H. pruinosus Rob. ♀, s. & c. p., freq.; (18) Augochlora pura Say ♀, s.; (19) A. similis Rob. ♀, s.; (20) Agapostemon viridula F. ♀, s.; *Vespidæ:* (21) Polistes pallipes Lep., s.; *Eumenidæ:* (22) Odynerus tigris Sauss., s.

DIPTERA—*Syrphidæ:* (23) Chrysogaster pictipennis Lw.; (24) C. nitida Wd.; (25) Eristalis dimidiatus Wd.; (26) Syritta pipiens L.; *Tachinidæ:* (27) Micropalpus fulgens Mg.; *Sarcophagidæ:* (28) Cynomyia mortuorum L.; (29) Helicobia helicis Twns.; *Muscidæ:* (30) Lucilia cornicina F.; (31) L. caesar L.; *Anthomyidæ:* (32) Phorbia acra Wlk.; (33) P. fusciceps Zett.—all s.

LEPIDOPTERA—*Rhopalocera:* (34) Pyrameis atalanta L.; (35) P. huntera F.; (36) Colias philodice Gdt., freq.—all s.

COLEOPTERA—*Coccinellidæ:* (37) Hippodamea 15-maculata Muls., s.

On the literature of *Camassia* see:

(1) Loew, Beobachtungen über Blumenbesuch von Insekten an Freilandpflanzen des Botanischen Gartens zu Berlin. Jahrb. Bot. Gartens Berlin **3**: 82, 117. (14, 49) 1884.—(2) Loew, Blüthenbiologische Beiträge, II. Pringsheim's Jahrbücher **23**: 76–77. 1892.

POLYGONATUM Adans.—This genus contains perennial herbs with pendulous, tubular bell-shaped, greenish flowers, which are homogamous, adapted to bumble-bees, or other long-tongued bees, though sometimes also visited by Lepidoptera and small insects which crawl into the tube. Self-pollination, as well as cross-pollination, may be effected by insects, or in some cases spontaneous self-pollination may occur by the anthers coming in contact with the stigma. That nectar is secreted by the ovary was known to Sprengel (1), while Bonnier (2) and Grassmann (7) have indicated the presence of septal glands.

We may suppose that the pendulous position of the flowers owes its origin to the fact that it renders them less convenient to other insects, but equally convenient to the higher bees, which are the most efficient pollinators; and that the resulting protection to pollen and nectar is merely an incidental effect.

On the theory that the flowers are adapted to bumble-bees, it is hard to understand the observation of Schulz (14) that the flowers of *P. verticillatum*, *multiflorum* and *officinale* are frequently perforated by them. In the case of the short-tongued species, like *B. terrestris*, we may suppose that the perforation is made because the bee cannot reach the nectar in the legitimate way. In the case of *P. verticillatum* the larger buds were also perforated. If the three species have nectar secreted prematurely in the bud, we might explain the behavior of the long-tongues by supposing that they have discovered this and cut through the tube without taking the trouble to find out whether the mouth is open or not.

POLYGONATUM GIGANTEUM Diet. *P. biflorum commutatum* (R. & S.) Morong.—The tube measures about 17^{mm} long and expands about 5^{mm} at the throat. The latter is obstructed by the filaments, which are inserted on the middle of the tube and are inclined inwards. The style is so short that, owing to the position of the flower, spontaneous self-pollination is impossible, though insects may with their proboscides carry pollen back to the stigma of the same flower. The flowers bloom from the 17th of May to the 14th of June. On May 23rd, 27th and June 1st I saw them visited by:

Apidæ: (1) Bombus vagans Sm. ♀, s. & c. p.; (2) Anthophora ursina Cr. ♀, s. & c. p.; (3) A. abrupta Say ♀, s. & c. p.

On the literature of *Polygonatum* see:

(1) Sprengel, Das entdeckte Geheimniss 198–9. 1793. *Convallaria polygonatum, multiflora.*—(2) Bonnier, Les Nectaires 23, 36, 86, 136,

192. 1879. *P. vulgare, multiflorum.*—(3) Müller, Alpenblumen 52–4. 1881. *C. polygonatum, verticillata.*—(4) Müller, Die Entwickelung der Blumenthätigkeit der Insekten. Kosmos **9**: 208. 1882. *C. polygonatum.*—(5) Durand, Sur quelques particularités d' organisation de la fleur des Polygonatum. Bull. mens. Soc. Linn. Paris **1882**: 322–3. (Just **10**²: 75).—(6) Loew, Blumenbesuch von Insekten an Freilandpflanzen. Jahrb. Bot. Gartens Berlin **3**: 99 (31) 1884. *P. officinale.*—(7) Grassmann, Die Septaldrüsen. Flora **67**: 118, 135. 1884. *P. officinale, multiflorum, verticillatum.*—(8) Engler, Liliaceæ. Engler u. Prantl, Die natürlichen Pflanzenfamilien 2: 15–16. 1887. (Just **16**¹: 555).—(9) Jordan, Beiträge zur physiol. Organographie der Blumen. Ber. der Deut. Bot. Ges. **5**: 330. 1887. *P. latifolium.* (Loew, Floristik 350).—(10) Pammel, On the pollination of Phlomis tuberosa and the perforation of flowers. Trans. St. Louis Acad. Sci. **5**: 254, 273. 1888. *C. polygonatum.*—(11) Kirchner, Flora von Stuttgart und Umgebung 70. 1888. *P. verticillatum.*—(12) Almquist, Om honings gropens s. k. fjäll hos Ranunculus och om honing salstringen hos Convallaria polygonatum och multiflora. Bot. Notiser **1889**: 66. (Just **16**¹: 533).—(13) Almquist, Ueber Honigerzeugung bei Convallaria polygonatum und multiflora. Bot. Centralb. **38**: 663. 1889. (Just **17**¹: 505).—(14) Schulz, Beiträge zur Kenntniss der Bestäubungseinrichtungen und Geschlechtsvertheilung bei den Pflanzen 2: 166, 224. Bibliotheca Botanica 17: —. 1890. (Just **18**¹: 524).—(15) MacLeod, Over de bevruchting der bloemen in het Kempisch gedeelte van Vlaanderen. Bot. Jaarboek **5**: 311–13. 1893. *P. multiflorum.*—(16) Loew, Blütenbiologische Floristik. 166, 350. 1894. *P. multiflorum, verticillatum, latifolium, officinale.*

SMILACINA STELLATA Desf. *Vagnera stellata* (L.) Morong.—This plant occurs on rich banks, sometimes forming rather large patches. It grows 4 or 5^{dm} high and bears a small terminal raceme of white flowers. The stem is bent to one side so that the axis of the raceme is directed horizontally. The flowers are arranged on the upper side so that the sepals are expanded horizontally, or nearly so. The flowers are therefore in the most favorable position for the visits of the less specialized insects, and the nectar and pollen are easily reached, the pollen in fact being completely exposed. The flowers are proterogynous, newly opened ones having receptive stigmas and closed anthers.

The indications point to an adaptation to the less specialized bees—*Andrenidæ*—which predominate during the blooming time and are the principal guests. The blooming time is from April 25th to May 12th. The following list was observed on April 30th:

BEES—*Apidæ:* (1) Ceratina tejonensis Cr. ♂, s.; (2) Nomada cressonii Rob. ♂, s.; *Andrenidæ:* (3) Andrena vicina Sm. ♀, s.; (4) A. cressonii Rob. ♀, s. & c. p.; (5) Halictus 4-maculatus Rob. ♀, s. & c. p.

freq.; (6) H. lerouxii Lep. ♀, s. & c. p.; (7) H. obscurus Rob. ♀, s. & c. p.; (8) H. stultus Cr. ♀, s. & c. p.; (9) H. sp. ♀, s. & c. p.; (10) Augochlora viridula Sm. ♀, s.; (11) A. labrosa Say ♀, s. & c. p.; (12) H. pura Say ♀, s. & c. p., freq.; (13) A. similis Rob. ♀, s. & c. p.; (14) Sphecodes smilacinæ Rob. ♀. s.

FLIES—*Empidæ:* (15) Empis humilis Coq. (MS.) s., freq.; *Bombylidæ:* (16) Bombylius major L., s.

SMILACINA RACEMOSA Desf. *Vagnera racemosa* (L.) Morong.—The stem is simple and inclined to one side so as to throw the terminal panicle into an horizontal position. The flower consists of six divergent stamens and the pistil. The segments of the perianth are very small and never enclose the stamens, the anthers being evident from the early bud. With the exception of the anthers all of the parts of the flower are white. By an increase in the number of flowers the panicle of this species is rendered even more conspicuous than the raceme of the preceding. The plant is more common, but is not often found in patches like *S. stellata.* The flowers are proterogynous with long lived stigmas. Cross-pollination is further facilitated by the stamens being strongly divergent. Spontaneous self-pollination can hardly occur.

There seems to be no nectar,[2] and the few visitors noted only sought for pollen. The blooming season is from May 7th to 30th. On the 17th, 18th and 23rd the following visitors were observed:

Andrenidæ (1) Halictus pectoralis Sm. ♀, c. p.; (2) H. 4-maculatus Rob. ♀, c. p.; (3) H. stultus Cr. ♀, c. p.

Scarabæidæ: (4) Trichius affinis Gory, f. p.

UVULARIA L.—Nectar is secreted by the sepals (Engler 2). In the case of *U. perfoliata*, Alice Carter (4) notes the abundant visits of bumble bees. At Madison, Wisconsin, Trelease (MS. notes) saw it visited by *Osmia albiventris* ♂. He regards the flower as probably spontaneously self-pollinating. On account of the shorter stamens, this may not be so likely as in the following.

UVULARIA GRANDIFLORA Smith.—Kerner (3) mentions this species as an example of simple autogamy.

The stems grow 2 or 3^{dm} high and bear one or two greenish yellow, pendulous flowers. The divisions of the perianth are closely approximated and twisted, which makes it difficult for all except the largest and strongest bees to enter. Nectar is secreted and lodged in a pit at the base of each segment.

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[2] This species has septal glands, according to Grassmann, Die Septaldrüsen. Flora **67:** 118. 1884.

Access to it is impeded by the segment lying close to the opposite filament. The long anthers surpass the style. The outer three begin to discharge their pollen before the others, and the dehiscence begins at the base of the anther and proceeds upwards. The flowers are homogamous. The three divisions of the style are widely divergent, so that the stigmas are protruded between the anthers. They thus come in the way of a bee crawling in between the anthers and sepals. A bee laden with pollen will invariably effect cross-pollination, if it visit the flower early, and it may accomplish the same result later. But after the line of dehiscence has reached the stigmas, there is a chance of spontaneous self-pollination. Cross-pollination commonly results in cross-fertilization between distinct plants.

The observations of Trelease, at Madison, give results essentially agreeing with the above account. He saw the flowers visited by bumble bees.

In my neighborhood, the blooming season is from April 12th to May 6th. April 20th, 23d, 25th, 26th and 29th, the following bees were observed on the flowers:

Apidæ: (1) Bombus separatus Cr. ♀, s.; (2) B. ridingsii Cr. ♀, s.; (3) B. americanorum F. ♀, s.; *Andrenidæ:* (4) Andrena vicina Sm. ♀, s. & c. p.; (5) A. pruni Rob. ♂, s.

The flowers are evidently adapted to Bombus females, the only sex flying during the blooming season. The pollen collecting visit of *Halictus cylindricus* ♀ in the Berlin Garden (1) has no significance.

On the literature of *Uvularia* see:

(1) Loew, Beobachtungen über Blumenbesuch von Insekten an Freilandpflanzen. Jahrb. bot. Gartens Berlin. **3**: 278 (76). 1884. *U. grandiflora* (flava)—(2) Engler, Liliaceæ. Engler u. Prantl, Die nat. Pflanzenfamilien. 2: 15. 1887.—(3) Kerner, Pflanzenleben **2**: 173, 330. 1891. —(4) Carter, Notes on pollination. Bot. Gaz. **17**: 21. Ja. 1892. (Just **20**[1]: 475).

TRILLIUM L.—From observations made in the Berlin Garden Loew (2) records that in *T. grandiflorum* Salisb. the flowers are proterandrous. They are white and expand about 9.5^{cm}. The stamens are longer than the pistil by about 5^{mm}. Loew was doubtful about the occurrence of nectar, but in the Botanical Garden at South Hadley, Mass., Miss Carter (3) noted its presence and says that it is secreted by septal glands. At first the mouth of the flower is closed by the anthers. Later the petals expand further, the stamens sep-

arate above, and the stigmas appear between them. She saw hive bees collecting the pollen. In view of Loew's observations and the statement of the Manual that the stamens exceed the stigmas, it is not easy to understand how the recurving stigmas will meet the anthers.

The white nodding flowers of *T. cernuum* L., according to Miss Carter, are slightly proterandrous, with a chance of spontaneous self-pollination by the stigmas recurving to meet the shorter stamens. She saw a bumble bee visiting the flowers for nectar.

T. erectum L., according to Loew, is a dark purple pollen-flower with offensive odor. The flower with its expanded or recurved petals measures about 7.5^{cm} across. In cases observed by him the anthers did not reach the height of the stigmas, but he mentions that the latter bend backwards. Miss Carter found the stigmas and anthers at nearly the same level. She regards spontaneous self-pollination as the rule. The Manual says that the stamens equal or exceed the stigmas. According to Weed (4) this species is proterandrous and adapted to cross-pollination. In New Hampshire he saw the flowers visited for pollen by two or three species of flesh-flies, among them *Lucilia cornicina* F. Miss Carter saw the flowers visited by four beetles, "certainly of little avail in cross-pollination and probably too late." The absence of nectar makes strong dichogamy improbable. The odor, color and the observed visits of flesh-flies suggest an adaptation to these insects, but the absence of nectar is hard to understand. The pinkish and white forms may be more attractive to insects, if they want the disagreeable odor and secrete nectar, but the greenish form is probably the most degraded. In fact this range of variation itself may be a sign of degradation. The flower seems to be losing its hold on insects and to form a transition between the other entomophilous species of *Trillium* and the still more degraded *T. sessile* and *recurvatum*.

TRILLIUM SESSILE L.—Loew (1, 2) classes this flower with *T. erectum*, but I have noted no disagreeable odor about it. We saw a beetle, *Cetonia aurata* L., gnawing the anthers. Miss Carter says that self-pollination seems inevitable.

In Patterson's Catalogue of Illinois Plants it is credited to Kankakee and Wabash counties. I have found it in only one locality. The sepals are not reflexed as in the next. The petals are greenish except at base, where they are dark pur-

ple, like the stamens and stigmas. This color is the only entomophilous character the plant shows. The stigmas are very large and have their edges thrown into convolutions. This great development seems to insure contact with the large anthers which surround them. On one occasion I found a number of beetles, *Centrinites strigicollis* Casey (Curculionidæ), among the anthers, feeding upon the pollen, and pairing. They seemed more likely to secure self-pollination, though in their slow movements to other plants cross-pollination might be effected. The flowers bloom from April 24th to May 15th.

TRILLIUM RECURVATUM Beck.—This is a common plant, blooming from April 8th to May 16th. The stems grow a few dm. high and bear single flowers, which are sessile upon the circle of three leaves. The sepals are green and reflexed. The petals are erect, arch over the stamens and are narrowed at base and tip. They are dark purple. The filaments and stigmas are of the same color, but the anthers are nearly black. The anthers are long and rigid, having a very broad connective which is produced above into a blunt point. They form a rather rigid cone over the pistil, so that the pollen can hardly be eaten or collected by insects. I find no nectar nor odor, in fact nothing to induce insect visits, except the purple color. It is possible that small flies resort to these flowers at night. The stigmas become elongated and recurved, so that with their convoluted edges they are quite likely to receive pollen from the anthers.

On the pollination of *Trillium* see:

(1) Loew, Weitere Beobachtungen über Blumenbesuch von Insekten an Freilandpflanzen. Jahrb. Bot. Gartens Berlin **4**: 149. 1886.—(2) Loew, Blüthenbiologische Beiträge. II. Pringsheim's Jahrbücher **23**: 78–9. 1892. (Just **19**^{1}: 417)—(3) Carter, Notes on pollination. Bot. Gaz. **17**: 20–1. 1892. (Just **20**^{1}: 475)—(4) Weed, Ten New England blossoms and their insect visitors 53–60. 1895.

MELANTHIUM VIRGINICUM L.—This plant is rare. It grows on prairies, sometimes in large patches. The stem rises from 1 to $1\frac{1}{2}^{m}$ high and is terminated by a large pyramidal panicle of white flowers. The old flowers, which turn greenish yellow, are persistent, so that they render the inflorescence more conspicuous.

The flowers are andro-monoecious, most of them being perfect, but the uppermost ones in the panicle are staminate. They expand horizontally from 15 to 30^{mm}. The sepals are

nearly heart-shaped with long claws. At the base of the blade of each sepal there is a shallow depression containing two yellow nectar glands. The nectar is thus completely exposed. The claw of each sepal bears a stamen with an extrorse anther held in such a position as to touch a large insect which sips the nectar. The three outer anthers dehisce first. The perfect flowers are proterandrous, the stigmas not becoming receptive until the anthers have fallen. The three styles are strongly divergent, so that the stigmas may touch the insects visiting the sepals for nectar.

The flowers show a very peculiar assemblage of visitors, mostly flies and beetles. The latter seem to be the ones for which the adaptations are intended. Of these *Trichius piger* is the most abundant visitor that I have observed, and it can readily affect pollination. The flowers are of rather large size, and, owing to their completely exposed nectar, admit insects which can obtain nectar but can hardly touch anthers or stigmas.

Melanthium Virginicum blooms from the 16th of June to the 11th of July. The list of visitors was observed on July 3d and 5th.

DIPTERA—*Syrphidæ:* (1) Mesograpta marginata Say; (2) Syritta pipiens L.; *Tachinidæ:* (3) Trichopoda pennipes F.; (4) Cistogaster occidua Wlk.; (5) C. immaculata Mcq.; (6) Jurinia smaragdina Mcq.; (7) Micropalpus fulgens Mg.; (8) Phorocera edwardsii Will.; (9) Atrophopoda singularis Twns.; *Sarcophagidæ:* (10) Sarcophaga cimbicis Twns.; *Muscidæ:* (11) Lucilia sp.; (12) L. cornicina F.; (13) Musca domestica L.; *Anthomyidæ:* (14) Anthomyia sp.; (15) A. albicincta Fll.—all s.

COLEOPTERA—*Lampyridæ:* (16) Photinus pyralis L.; *Scarabaeidæ:* (17) Trichius piger F. freq.; *Chrysomelidæ:* (18) Diabrotica atripennis Say; *Mordellidæ:* (19) Mordella melaena Germ.; (20) M. marginata Melsh.; *Curculionidæ:* (21) Centrinites strigicollis Casey—all s.

HYMENOPTERA—*Andrenidæ:* (22) Halictus confusus Sm. ♀; *Sphecidæ:* (23) Sphex ichneumonea L.; *Chalcididæ:* (24) Perilampus triangularis Say—all s.

Carlinville, Illinois.

147

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FLOWERS AND INSECTS. XVII

CHARLES ROBERTSON

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FLOWERS AND INSECTS. XVII.

CHARLES ROBERTSON.

For a more extended title of this series I have adopted that of "Contributions to an account of the ecological relations of the entomophilous flora and the anthophilous insect fauna of the neighborhood of Carlinville, Illinois." The following papers should be regarded as parts of the same series: Flowers and Insects: Umbelliferæ. *Trans. St. Louis Acad. Science* **5**: 449–460. 1890; Asclepiadaceæ to Scrophulariaceæ, *ibid.* **5**: 569–598. 1891; Labiatæ. *ibid.* **6**: 101–131. 1892. (no. 4); Rosaceæ and Compositæ, *ibid.* **6**: 435–480. 1894. (no. 14); Flowers and Insects, *ibid.* **7**: 151–179. 1896. (no. 6); The Philosophy of Flower Seasons, American Naturalist **29**: 97–117. 1895. The cases of some plants, such as those observed in Florida, which properly do not come under the title, are distinctly specified.

The present paper discusses a number of plants, which, although not akin, should be compared because of the influence which their greenish yellow colors have been considered to have in determining the character of the insect visits.

CAULOPHYLLUM THALICTROIDES (L.) Michx. is a perennial plant, rather frequent in rich woods, and blooming a short time, April 23d to May 7th. The stems grow several decimeters high and bear single small loose panicles of yellowish green flowers. The flowers expand horizontally about 10^{mm}, and, I think, remain open at night. Each of the six sepals has, lying upon its base, a short petal which is somewhat kidney-shaped, being expanded into a nectar gland as wide as the sepal. The style is very short and is tipped by a small stigma, which is receptive before the anthers dehisce. From the shortness of the stamens, as well as their later dehiscence, I think that spontaneous self-pollination does not occur. According to the views usually held with regard to

flowers of like color and nectar exposure, we might expect a strong predominance of flies. My observations do not show this.

With the exception of no. 18, taken April 23d, the following list was observed on May 1st:

HYMENOPTERA—*Andrenidæ*: (1) Halictus confusus Sm. ♀, s. & c. p.; (2) H. 4-maculatus Rob. ♀, s.; (3) Augochlora viridula Sm. ♀, s.; *Braconidæ*: (4) Bracon trifolii Ashm.; (5) B. veronniæ Ashm; (6) Microgaster gelechiæ Riley, ab.; (7) Opius ruficeps Prov.; (8) Dacnusa flavicincta Ashm.; *Chalcididæ*: (9) Prosacantha illinoensis Ashm. (MS)—all s.

DIPTERA—*Mycetophilidæ*: (10) Dynatosoma thoracica Coq. (MS); *Empidæ*: (11) Rhamphomyia piligeronis Coq. (MS); *Syrphidæ*: (12) Chilosia capillata Lw.; (13) Melanostoma obscurum Say; (14) Rhingia nasica Say; *Anthomyidæ*: (15) Hylemyia plumosa Coq. (MS); (16) Mydæa flavipes Coq. (MS); *Oscinidæ*: (17) Chlorops trivialis Lw.—all s.

COLEOPTERA—*Mordellidæ*: (18) Mordellistena biplagiata Hel.; *Curculionidæ*: (19) Idiostethus subcalvus Casey, both s.

PTELEA TRIFOLIATA L.—According to Hildebrand (1) and Kerner (3), the flowers are staminate and perfect. Urban (2) indicates that *Ptelea* is diœcious, and that self-pollination is impossible. As far as I have observed, it has appeared that this species is diœcious. I could find no perfect flowers.

The greenish white blossoms expand from 10 to 15^{mm} and are crowded in compound cymes, which are nearly level topped and form convenient resting places for insects. In both forms nectar is secreted by the gynophore and is slightly concealed by the hairy bases of the filaments.

The following table shows the kinds of insects taken on *Xanthoxylum Americanum* and *Ptelea trifoliata*, the former blooming from April 12th to 28th and the latter from May 8th to June 12th:

	Other Hymenoptera	Apidæ	Andrenidæ	Diptera	Lepidoptera
Xanthoxylum Americanum (39)	0	6	19	13	1
Ptelea trifoliata (51)	12	1	22	14	2

The difference in Apidæ may be partly on account of the former having the nectar more concealed, but is mainly, I think, on account of the blooming time. At any rate, three of the Apidæ taken on *Xanthoxylum* have finished their flight before

Ptelea goes out of bloom. Of the twelve species of lower Hymenoptera taken on *Ptelea*, not one is flying during the period of *Xanthoxylum*. The inflorescence of *Ptelea* is more favorable for their visits.

The principal pollinators are Andrenidæ. May 28th, 30th and June 1st, 4th and 8th the following list was observed:

HYMENOPTERA—*Apidæ*: (1) Apis mellifica L. ☿, s., freq.; *Andrenidæ*: (2) Halictus coriaceus Sm. ♀, s.; (3) H. ligatus Say ♀, s.; (4) H. lerouxii Lep. ♀, s.; (5) H. cressonii Rob. ♀, s. & c. p.; (6) H. pilosus Sm. ♀, s.; (7) H. confusus Sm. ♀, s. & c. p.; (8) H. stultus Cr. ♀, s. & c. p.; (9) H. tegularis Rob. ♀, s. & c. p.; (10) Agapostemon radiatus Say, ♀, s.; (11) Augochlora pura Say, ♀ s.; (12) Andrena roberteonii D. T., ♀, s. & c. p., freq.; (13) A. platyparia Rob. ♂♀, s. & c. p.; (14) A. cressonii Rob. ♀, s.; (15) A. bipunctata Cr. ♀, s. & c. p., freq.; (16) A. nuda Rob. ♀, s. & c. p.; (17) A. rugosa Rob. ♀, s.; (18) A. spiræana Rob. ♂♀, s.; (19) A. hippotes Rob. ♀, s. & c. p., ab.; (20) A. claytoniæ Rob. ♀, s., freq.; (21) A. cratægi Rob. ♀, s. & c. p.; (22) Sphecodes confertus Say ♀, s., freq.; (23) Prosopis modesta Say, ♂, s.; *Eumenidæ*: (24) Eumenes fraternus Say, s.; (25–27) Odynerus spp., s.; (28) O. unifasciatus Sauss., s.; (29) O. tigris Sauss., s.; (30) O. foraminatus Sauss., s.; *Crabronidæ*: (31) Oxybelus illinoensis Rob. (MS), s.; *Philanthidæ*: (32) Cerceris compar Cr., s.; *Sphecidæ*: (33) Ammophila vulgaris Cr., s.; *Scoliidæ*: (34) Elis confluenta Say, s.; *Chalcididæ*: (35) Leucospis affinis Say, s.

DIPTERA—*Stratiomyidæ*: (36) Stratiomyia meigenii Wd.; *Conopidæ*: (37) Conops brachyrhynchus Mcq., s.; (38) Myopa vesiculosa Say, s.; *Syrphidæ*: (39) Sphærophoria cylindrica Say, s.; (40) Myolepta nigra Will., s.; (41) Volucella vesiculosa F., s.; (42) Mallota cimbiciformis Fil. f. bautias Wlk., s.; (43) Syritta pipiens L., s.; *Tachinidæ*: (44) Trichopoda sp., s.; (45) Jurinia smaragdina Mcq., s.; (46) J. apicifera Wlk., s.; (47) Micropalpus fulgens Mg., s.; *Muscidæ*: (48) Lucilia cornicina F., s.; *Anthomyidæ*: (49) Phorbia fusciceps Zett.

LEPIDOPTERA—*Rhopalocera*: (50) Neonympyha eurytris F., s.; *Heterocera*: (51) Alypia octomaculata Hbn.

Trelease (MS notes) captured the following insects on the flowers:

HYMENOPTERA—*Apidæ*: (1) Psithyrus (Apathus) laboriosus F., ♀; (2) Nomada sp.; *Andrenidæ*: (3) Halictus pilosus Sm., ♀; (4) Andrena pruni Rob., ♀; (5) A. illinoensis Rob., ♀; (6) A. cratægi Rob., ♀; (7) Agapostemon viridulus F., ♀; (8) Sphecodes confertus Say, ♀; (9) Prosopis modesta Say, ♀; *Vespidæ*: (10) Vespa germanica F.; (11) Polistes metricus Say; *Eumen-*

idæ: (12) Odynerus albophaleratus Sauss.; *Crabronidæ*: (13) Oxybelus 4-notatus Say; *Philanthidæ*: (14) Cerceris pedalis Cr.

COLEOPTERA—*Coccinellidæ*: (15) Analia bipunctata L.; *Dermestidæ*: (16) Anthrenus scrophulariæ L.; *Lampyridæ*: (17) Chauliognathus pennsylvanicus De G.; and other insects which I have not seen, probably flies.

On the literature of *Ptelea* see:

(1) Hildebrand, Geschlechtsvertheilung bei den Pflanzen, **11**: 26. 1867.—(2) Urban, Zur Biologie und Morphologie der Rutaceen, Jahrb. bot. Gartens Berlin **2**: 397–8. 1883. (Just **11**[1]: 497.)—(3) Kerner, Pflanzenleben **2**: 295. 1891. (Just **18**[1]: 486.)

RHAMNUS L.—The species which have been studied are diœcious—*R. cathartica* (Darwin 7), *saxatilis* and *tinctoria* (Kerner 19)—or with flowers perfect, as in *R. Frangula* and *pumila* (Müller 3, 11), the former being proterandrous and the latter homogamous. *R. cathartica* has four sub-forms (Darwin 7), and *Frangula* shows a tendency to produce a long and short-styled form, as in our *R. lanceolata* (Schulz 17).

The flowers are small, greenish, with easily accessible nectar and have been considered to be adapted to flies (Delpino 5, Müller 12, 13), but this does not seem to be supported by sufficient data. Still more extreme is the limitation of the proper visitors to flesh-flies (Kerner 19). My list of visitors of *R. lanceolata* resembles those of white or yellow flowers with similarly placed nectar and blooming about the same time. The results of the observation of different species in separate regions is given in the following table:

	Apidæ	Andrenidæ	Other Hymenop	Diptera	Coleoptera	Total
Rhamnus lanceolata, Illinois	4	23	3	22		52
R. Frangula, Low Germany, Müller (3, 10)	2	1	2	1		6
R. Frangula, Flanders, MacLeod (20)	2			1	1	4
R. pumila, Alps, Müller (11)			4	8	5	17

RHAMNUS LANCEOLATA Pursh.—According to Darwin (7), this species is dimorphous, but not properly heterostyled. The small trees grow as high as three or four meters and bear

numerous greenish flowers which appear with the leaves. The stamens are exserted so that the pollen may be eaten by Syrphidæ or collected by Andrenidæ, but the style is short and included. The calyx tube is about 2^{mm} deep and 1^{mm} wide. Consequently the nectar, which is secreted by a disk lining the tube, is readily accessible to small, short-tongued insects. From their structure and blooming time, April 23d to May 10th, the flowers seem to be specially adapted to Andrenidæ, but they are also visited less abundantly and less efficiently by flies. On the 1st and 2d of May I captured the following visitors:

HYMENOPTERA—*Apidæ:* (1) Apis mellifica L. ☿, s., one; (2) Bombus americanorum F. ♀, s.: (3) Ceratina dupla Say ♂, s.; (4) Nomada maculata Cr. ♀, s.; *Andrenidæ:* (5) Halictus foxii Rob. ♀, s. and c. p., freq.; (6) H. arcuatus Rob. ♀, s. and c. p.; (7) H. forbesii Rob. ♀, s. and c. p.; (8) H. lerouxii Lep. ♀, s. and c. p.; (9) H. fasciatus Nyl. ♀, s. and c. p., ab.; (10) H. pilosus Sm. ♀, s. and c. p., freq.; (11) H. confusus Sm., ♀, s. and c. p., freq.; (12) H. pruinosus Rob. ♀, s.; (13) H. illinoensis Rob. ♀, s.; (14) H. zephyrus Sm. ♀, s. and c p.; (15) H. stultus Cr. ♀; (16) Agapostemon radiatus Say ♀, s., freq.; (17) Augochlora viridula Sm. ♀, s.; (18) A. pura Say ♀, s. and c. p., freq.; (19) A. labrosa Say ♀, s. and c. p.; (20) Andrena erythrogastra Ashm. ♂, s.; (21) A. mandibularis Rob. ♀, s.; (22) A. nasonii Rob. ♀, s. and c. p.; (23) A. cressonii Rob. ♂♀, s. and c. p., ab.; (24) A. bipunctata Cr ♂, s.; (25) A. ziziæ Rob. ♂♀, s. and c. p., freq.; (26) A. cratægi Rob. ♂, s.; (27) Sphecodes mandibularis Cr. ♀, s.; *Eumenidæ:* (28) Eumenes fraternus Say, s.; (29) Odynerus tigris Sauss., s.; *Tenthredinidæ:* (30) Dolerus arvensis Say, s.

DIPTERA—*Empidæ:* (31) Rhamphomyia priapulus Lw.; *Syrphidæ:* (32) Pipiza femoralis Lw.; (33) Chrysogaster nitida Wd.; (34) Syrphus ribesii L.; (35) S. americanus Wd.; (36) Xanthogramma felix O. S.; (37) Allograpta obliqua Say, freq.; (38) Mesograpta geminata Say, ab.; (39) M. marginata Say; (40) Sphærophoria cylindrica Say, freq.; (41) Helophilus similis Mcq.; (42) Syritta pipiens L.; *Tachinidæ:* (43) Cyphocera fuesta V. d. W.; *Sarcophagidæ:* (44) Cynomyia mortuorum L.; (45) Sarcophaga ægra Wlk.; (46) S. cimbicis Twns.; *Muscidæ:* (47–48) Lucilia spp.; (49) L. latifrons. Schin.; *Cordyluridæ:* (50) Scatophaga squalida Mg.; *Anthomyidæ:* (51) Phorbia acra Wlk.; (52) P. fusciceps Zett.—all s. or f. p.

On the literature of *Rhamnus* see:

(1) Darwin, on the two forms, or dimorphic condition, in the species of *Primula*, and on their remarkable sexual relations; Journ. Linn. Soc. Bot. **6**:95. 1862—*R. lanceolata.* (2) Hildebrand, Geschlechtsvertheilung bei den Pflanzen **9**:40. 1867—*R. cathartica, lanceolata.* (3) Müller, Befruchtung

der Blumen 152. 1873—*R. Frangula.* (4) Kerner, Die Schutzmittel des Pollens 56. 1873. (5) Delpino, Ulteriori osservazioni, pt. II, fasc. 2:20, 214, 300, 316, Att. Soc. Ital. Sci. Nat., Milano **16**:168. 1873; **17**:——. 1874 —*R. cathartica, Frangula, alterna* (Just **2**:895). (6) Lubbock, British wild flowers in relation to insects 79. 1875—*R. cathartica, Frangula, lanceolata.* (7) Darwin, Forms of flowers, 273–7. 1877—*R. cathartica, lanceolata, Frangula.* (8) Bonnier, Les Nectaires, Ann. Sci. Nat. Bot. **8**:39. 1878. *R. Frangula, alpina*, inconspicuous flowers abundantly visited. (9) Dodel-Port, Die Liebe der Blumen **4–5**:185–240. 1880—*R. cathartica* (Just **8**^{1}:183). (10) Müller, Weitere Beobachtungen, II, Verh. naturhist. Ver. preuss. Rheinl. u. Westf. 212. 1879—*R. Frangula.* (11) Müller, Alpenblumen 169–71. 1881—*R. pumila.* (12) Müller, Geschichte der Erklärungsversuche in Bezug auf die biologische Bedeutung der Blumenfarben, Kosmos **12**:125, N., 1882 (Just **9**^{1}:506). (13) Müller, Die biologische Bedeutung der Blumenfarben, Biol. Centralblatt **3**:99, Ap. 1883. (14) Müller, Die Stellung der Honigbiene in der Blumenwelt, III, Deutsche Bienenzeit. **39**:157–61. 1883—*R. pumila*, Apis wanting. (15) Müller, Fertilization of flowers, 163–4. 1883—*R. Frangula, cathartica, lanceolata, pumila.* (16) Kirchner, Flora von Stuttgart und Umgebung, 363–4. 1888—*R. Frangula, cathartica.* (17) Schulz, Beiträge zur Kenntniss der Bestäubungseinrichtungen und Geschlechtsvertheilung bei den Pflanzen, **1**:31. 1888; **2**:61, 185. 1890. Bibliotheca Botanica, 10 und 17—*R. Frangula, cathartica, pumila.* (18) Trelease, North American Rhamnaceæ, Trans., St. Louis Acad. Sci. **5**:359. (19) Kerner, Pflanzenleben, **2**:169, etc. 1891—*R. cathartica, saxatilis, tinctoria.* (20) MacLeod, Over de bevruchting der bloemen in het kempisch gedeelte van Vlaandern, Bot. Jaarbock. **6**:247–9, 438, 1894—*R. Frangula, cathartica.* (21) Loew, Blütenbiologische Floristik **36**:215. 1894—*R. pumila, Frangula, cathartica, saxatilis.*

RHUS L.—The species are said to be polygamous or polygamo-diœcious. It might be better to call them diœcious, though of a recent form, for the staminate and pistillate flowers have large rudiments of pistils and stamens, and there is a tendency for them to revert to the perfect condition. Müller (4, 14) and Kerner (16) mention *R. Cotinus* as polygamous; but in Halle and in South Tyrol Schulz (15) found it to be diœcious, though it appears (Loew[1] 20) that in the former locality he afterwards found polygamous examples. In the manual *R. typhina* is called polygamous, while Müller calls it diœcious.

[1] In the Floristik, unfortunately, Loew mentions an author without citing any of the separate papers listed under that author's name.

Meehan (6, 18) referring to the fact that *R. copallina*, *venenata* and *Toxicodendron* are variously classed as diœcious, polygamo-diœcious, or polygamous, insists that they and *R. cotinoides* are all truly diœcious. I regard *R. glabra* and *Canadensis* as diœcious.

In regard to the staminate, perfect, and pistillate flowers of *R. Cotinus*, Müller observes that they decrease in size in the order mentioned, and that, consequently, most insects visit them in the most advantageous order. Schulz failed to confirm the latter observation. In *R. glabra* and *Canadensis*, I think insects prefer the staminate flowers, partly because they are more conspicuous and because they contain pollen as well as nectar, and that the order of their visits is advantageous. However, I do not believe that natural selection has operated in producing the difference, and so hold that it would be erroneous to say that the difference exists to secure the advantage. As a rule stamens are more conspicuous than pistils, and it is quite obvious that a small flower containing five stamens will be more evident than one containing a single pistil. The larger perianth may be explained as existing to support, and at first to protect, this exterior set of organs.

Two effects upon the insect visitors have been attributed to the dull yellow colors of *Rhus*. Müller says that *R. Cotinus*, like all other flowers of a dull yellow color, is almost completely avoided by Coleoptera. The general proposition is denied by Bonnier (9), and Schultz says that it is not true for *R. Cotinus* in the Tyrol, where he found many beetles among the visitors. *Pastinaca*, on which I have taken forty species of beetles, is mentioned by Müller as an example of the same kind.

The idea that the flowers of *Rhus* were specially attractive to flies (macromyiophilous) seems to have originated with Delpino (5). The "Tipo ramnaceo," which he regards as macromyiophilous, includes the greenish yellow species of *Rhus*, *Rhamnus*, *Euonymus*, *Euphorbia*, etc. In a special paper on the biological significance of flower-colors Müller (12) says that greenish yellow colors are frequent in flowers among whose visitors the

larger Diptera predominate. Both authors distinguish these cases from the dark colored flowers, like *Stapelia*, *Asimina*, etc., which they consider to be adapted to flesh flies. The view in regard to the greenish yellow flowers does not seem to have been supported, if not entirely refuted, by subsequent investigations. Kerner's view (16) that these colors are specially attractive to flesh flies was never held either by Delpino or Müller, and so may be considered to be supported neither by authority nor recorded observations. Of the greenish yellow flowers which bloom in my neighborhood I have found a preponderance of general Diptera on none except *Sassafras*. Indeed I expect *Smilax herbacea* and *S. ecirrhata* to show a preponderance of flesh flies, but they differ from the others, and from all of the cases cited by Kerner, in having a scent of carrion.

The following table gives results of observations of insect visitors of *Rhus* in cases in which the species have been identified. The Andrenidae and lower Hymenoptera preponderate over the Diptera. In the Tyrol Schulz saw *R. Cotinus* very abundantly visited by a set of insects which in a general way must resemble my list for *R. glabra* (19).

	Apidæ	Andrenidæ	Other Hymenop	Dipteria	Other insects	Total
Rhus Cotinus — Low Germany — Müller (4,14)	1	3	6	6	1	17
Rhus typhina — Low Germany — Müller (4,14)	1	1	..	..	1	3
Rhus glabra—Illinois (19)	3	16	13	25	1	58
Rhus Canadensis — Illinois (19)	2	21	1	9	..	33

RHUS CANADENSIS Marsh. *R. aromatica* Ait. This is a slender shrub growing on high creek banks, the stems rising from 1 to 2^{m} high. The branchlets are terminated by clusters of about three small, head-like racemes, which measure 8–10^{mm} in length, and appear before the leaves. The flower buds escape from hibernacula whose scales still clasp the bases of the stalks.

The flowers are small, greenish yellow, with short petals. They are quite shallow, the nectar being almost freely exposed. Nectar is secreted by five orange colored glands situated between the bases of the filaments. The staminate flowers have the petals a little longer and more often expanded, so that this form is the more conspicuous. The nectar glands are larger, more triangular and united at base. The pistil is so strongly developed that the flower appears to be perfect. In the pistillate flower the nectar glands are more bilobed. The stamens are of normal form, but greatly reduced in size, and are without pollen. Both forms are abundantly visited by insects.

In the case of *Xanthoxylum Americanum*, which blooms from April 12th to 28th, and *Ptelea trifoliata*, blooming from May 8th to June 12th, we have observed that the lists differ in the absence of the lower Aculeata from *Xanthoxylum*. This was explained as a result of the difference in their blooming time. If we compare *R. Canadensis*—April 4th to 27th—with *R. glabra*—June 8th to 24th—we find the same result. In the former case not one of the lower Aculeata occurring on *Ptelea* flies while *Xanthoxylum* is in bloom. Here we have a similar condition, for *Polistes metricus* is the only one taken on *R. glabra* which is flying during the flower season of *R. Canadensis*. The large inflorescences of *Ptelea* and *R. glabra* form more convenient resting places for these often large straddling insects. The differences in the inflorescences may be accounted for partly by the difference in the composition of the late insect fauna; but the early months, when there is apt to be frost, are not favorable for the development of large flower clusters. Then, too, before the leaves appear, the smaller clusters are sufficiently conspicuous. Other differences in the lists are connected with the blooming time, viz., the advent of *Prosopis*, substitution of two late *Colletes* for the early *C. inaequalis*, and an increase of *Halictus* associated with the decline of the vernal species of *Andrena*.

The following visitors of *R. Canadensis* were taken on April 4th, 10th, 12th and 19th:

HYMENOPTERA—*Apidæ*: (1) Ceratina tejonensis Cr., ♂; (2) Nomada

maculata Cr., ♂♀, freq.; *Andrenidæ*: (3) Halictus sp. ♀; (4) H. foxii Rob., ♀, freq.; (5) H. forbesii Rob., ♀, freq.; (6) H. ligatus Say, ♀; (7) H. cressonii Rob., ♀; (8) H. zephyrus Sm., ♀, freq.; (9) H. stultus Cr., ♀; (10) Agapostemon texanus Cr., ♀; (11) Augochlora pura Say, ♀; (12) Andrena sp. ♂♀, freq.; (13) A. vicina Sm., ♂♀, freq.; (14) A. erythrogastra Ashm., ♀; (15) A. mandibularis Rob., ♂♀, freq.; (16) A. illinoensis Rob., ♀; (17) A. cressonii Rob., ♂; (18) A. bipunctata Cr., ♂♀, freq.; (19) A. rugosa Rob., ♂♀, ab.; (20) A. mariæ Rob., ♂, freq.; (21) A. claytoniæ Rob., ♂♀, ab.; (22) A. forbesii Rob., ♀; (23) Colletes inæqualis Say, ♂, freq.; *Ichneumonidæ*: (24) Lampronota coxalis Ashm. (MS.), ♀, type.

DIPTERA—*Empidæ*: (25) Rhamphomyia priapulus Lw.; *Syrphidæ*: (26) Syrphus americanus Wd., freq.; (27) S. ribesii L.; (28) Eristalis dimidiatus Wd.; *Tachinidæ*: (29) Gonia frontosa Say, freq.; *Sarphagidæ*: (30) Cynomyia mortuorum L.; *Muscidæ*: (31) Lucilia cornicina F., freq.; *Sciamyzidæ*: (32) Tetanocera pictipes Lw.; *Lonchæidæ*: (33) Lonchæa polita Say—all sucking.

On the literature of *Rhus* see:

(1) Hildebrand, Geschlechtsvertheilung bei den Pflanzen **10**. 1867—*R. Toxicodendron*. (2) Axell, Om anordningarna für de fanerogama växternas befruktning 47. 1869—*R. Toxicodendron*. (3) Delpino, Altri apparecchi dicogamici recentemente osservati, Nuovo Giorn. Bot. Ital. **2**:52. 1870. (4) Müller, Befruchtung der Blumen 157–8. 1873. (5) Delpino, Ulteriori osservazioni, Part II, fasc. **2**:20, 214, 300. 1875, Atti. Soc. Ital. Sci., Milano **16**: 168. 1873; **17**. 1874 (Just. **2**: 882, 895). (6) Meehan, On hermaphroditism in *Rhur cotinus* and in *Rhus glabra*, Proc. A. A. A. S., 1873; B. 73–5. (7) Meehan, On self-fertilization and cross-fertilization in flowers, The Penn Monthly, N.1876 (Just. **4**: 939). (8) Müller, Das Variiren der Grösse gefärbter Blüthenhüllen und sein Einfluss anf die Naturzüchtung der Blumen, Kosmos **2**: 132–3. 1887—*R. Cotinus, typhina* (Just. **5**: 740–1). (9) Bonnier, Les Nectaires, Ann. Sci. Nat. Bot. VI, **8**: 71. 1878—*R. Cotinus*. (10) Patton, Observations on the genus Macropis, Am. Journ. Sci. and Arts III, **18**: 211, 212. 1879—*R. glabra typhinæ* (Just **7**[1]: 145). (11) Bontroux, Sur l'habitat et la conservation des lévures spontanées, Bull. Soc. Linn. Normandie, III, **6**. 1881—*R. Cotinus* (Just **13**[1]: 745). (12) Müller, Die biologische Bedeutung der Blumenfarben, Biol. Cent. **3**: 99. 1883 (Just **9**[1]: 506). (13) Müller, Die Stellung der Honigbiene in der Blumenwelt, III, Bienenzeit, Jahrg. **39**: 157–161. 1883—*R. typhina* (Just **11**[1]: 476). (14) Müller, Fertilization of Flowers, 166–7. 1883. (15) Schulz, Beiträge Zur Kenntniss der Bestäubungseinrichtungen and Geschlechtsvertheilung bei den Pflanzen **2**: 62–4, 186. 1890, Bibliotheca Botanica **17** (Just **18**[1]: 517). (16) Kerner, Pflanzenleben **2**: 192, 297. 1891; Kerner & Oliver **2**: 173, 197, 297. 1895 (Just **17**[1]: 531, 2; **18**[1]: 486). (17) Engler, Anacardiaceæ, Engler u. Prantl, Die nat. Pflanzenfamilien, **73**: 142. 1892 [Th. III, Abth. S]—*R. Cotinus* (Just **20**[1]: 481). (18)

159

Meehan, Contributions to the life histories of plants, VIII, Proc. Acad. Nat. Sci., Phila., 1892, 369–71 (Just **20**[1]: 494). (19) Robertson, Flowers and insects, XII, Bot. Gaz. **19**: 111, 112. 1894. (20) Loew, Blütenbiologische Floristik, 215 — *R. Cotinus.*

SASSAFRAS OFFICINALE Nees. *S. Sassafras* (L.) Karst. Hildebrand (1) observes that the pistillate and staminate flowers each have rudiments of the other set of organs, being what Kerner (2) calls pseudo-hermaphrodite. According to Bentham and Hooker's Genera Plantarum, and Gray's Manual this species is dioecious; and that is what I have always regarded it, though I paid attention to little except the insect visitors. Chapman, in the Flora of the Southern States, calls it diœciously polygamous, while Kerner calls it polygamous. My observations were made upon trees which I supposed bore only staminate flowers.

The flowers are greenish yellow, expand about 8 or 9^{mm}, and are arranged in corymbose clusters, which appear with the leaves. There are nine stamens. The three inner ones have at base of each a pair of stalked glands which secrete nectar. The nectar is therefore fully exposed on a convex surface.

There are a number of early flowers with convenient nectar, some of which on account of their greenish yellow color have been supposed to be principally visited by flies. In all except *Caulophyllum* and *Sassafras* the less specialized bees, Andrenidæ, outnumber the flies. *Sassafras* is the only one on which the flies clearly preponderate. In most of the species the nectar tends to collect in shallow cups, which make it very convenient for the Andrenidae, while in *Caulophyllum* and *Sassafras* it is secreted on convex surfaces, which make it more convenient for flies and less convenient for the little bees. However, the exposure of the nectar does not explain why *Sassafras* shows a preponderance of Diptera, but only why it shows more flies than the other greenish yellow flowers blooming about the same time. During the blooming season, April 19th–May 7th, the flowers are exposed to none of the lower aculeate Hymenoptera, except eight species of *Vespa* and *Polistes* and *Priocnemis conicus*. The last is the only one of these taken on the flowers. It happens to be the only one of the *Pompilidæ* flying during the blooming season. Sup-

pose that *Sassafras* bloomed in the last of July, what would there be to keep it from being visited by several of the nineteen species of *Pompilidæ* flying at that time, or by many other short-tongued Aculeata which are then very abundant? In the south the lower Aculeata begin to fly earlier, and I should expect *Sassafras*, and many other early flowers with exposed or slightly concealed nectar, to show an increase in the proportion of these insects as we move in that direction.

The following insects were taken on the flowers on April 27th and 29th:

HYMENOPTERA—*Andrenidæ*: (1) Halictus cressonii Rob., ♀; (2) H. confusus Sm., ♀, s. & c. p.; (3) H. stultus Cr., ♀; (4) Andrena sp. ♀; (5) A. illinoensis Rob., ♂; (6) A. hippotes Rob., ♂; *Pompilidæ*; (7) Priocnemis conicus Say; *Chalcididæ*: (8) Eurytoma sp.; *Ichneumonidæ*: (9) Pimpla annulipes Br.; (10) Idiolespa anilis Grav.; (11) Ophion bifoveolatum Br.; *Tenthredinidæ*: (12) Hylotoma mcleayi Leach; (13) Monophadnus medius Norton.

DIPTERA—*Simulidæ*: (14) Simulium pecuarum Riley; *Bibionidæ*: (15) Bibio pallipes Say, freq.; (16) B. femorata Wd.; *Stratiomyidæ*: (17) Sargus iridis Say; *Empidæ*: (18) Empis compta Coq. (MS); (19) Rhamphomyia ravida Coq. (MS); (20) R. piligeronis Coq. (MS.); (21) R. priapulus Lw., freq.; (22) R. mutapilis Lw., freq.; (23) R. exigua Lw.; *Syrphidæ*: (24) Chilosia versipellis Will., freq.; (25) Chrysogaster nitida Wd.; (26) Platycheirus hyperboreus Staeg.; (27) Syrphus americanus Wd.; *Tachinidæ*: (28) Nemoræa aldrichii Twns.; (29) Gonia frontosa Say; (30) Micropalpus fulgens Mg.; (31) Phorocera edwardsii Will.; *Sarcophagidæ*: (32) Cynomyia mortuorum L., freq.; (33) Sarcophaga sp.; (34) S. cimbicis Twns.; *Muscidæ*: (35) Lucilia sp.; (36) L. cæsar L.; (37) L. cornicina F.; (38) Morellia micans Mcq., freq.; *Anthomyidæ*: (39) Homalomyia prostrata Rossi; (40) Caricea antica Wlk.; (41) Phorbia acris Wlk., ab.; (42) P. fusciceps Zett., ab.; *Cordyluridæ*: (43) Scatophaga squalida Mg.; *Oscinidæ*: (44) Chlorops trivialis Lw.; *Agromyzidæ*: (45) Agromyza latipes Mg.; (46) A. æneiventris Fll.

COLEOPTERA—*Lampyridæ*: (47) Telephorus bilineatus Say, freq.; *Œdemeridæ*: (48) Asclera puncticollis Say.

HEMIPTERA—*Corimelænidæ*: (49) Corimelæna pulicaria Ger.—all only sucking, except No. 2.

On the literature of *Sassafras* see:

(1) Hildebrand, Geschlechtsverteilung bei den Pflanzen 9. 1867. *Laurus Sassafras*: (2) Kerner, Pflanzenleben **2**: 297. 1891. Oliver, translation, 288 1895—*L. Sassafras*.

CARLINVILLE, ILLINOIS.

FLOWERS AND INSECTS:

ASCLEPIADACEÆ to SCROPHULARIACEÆ.

BY CHARLES ROBERTSON.

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165

FLOWERS AND INSECTS,
ASCLEPIADACEÆ to SCROPHULARIACEÆ.

By Charles Robertson.

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The following paper belongs with a series of papers begun in the Botanical Gazette in May, 1889, and giving an account of observations made at Carlinville, Ill., in 1886 and following years. The paper on "Umbelliferæ," in the fifth volume of these Transactions, pp. 449–460, belongs with the same series. 8

A bibliography of the literature of the fertilization of flowers by D'Arcy W. Thompson will be found in Hermann Müller's "Fertilization of Flowers," 599–634. This list includes works published up to 1883. A continuation of this bibliography up to 1889, by J. McLeod, will be found in the Botanisch Jaarboek, Gent, Tweede Jaargang, 1890

ASCLEPIADACEÆ.

In the Botanical Gazette, vol. xii., 207–216, 244–250, I have given an account of the following species of *Asclepiadaceæ.* I shall now add a list of visitors of each of them. The name of each insect is followed by c., h., t., p., or sp., according as the corpuscula were found attached to the claws, hairs of the legs, tongue, pulvilli, or spurs of the tibiæ. In most cases, however, the pulvilli and spurs are counted as hairs and marked "h."

Asclepias verticillata, L.—On 15 days, between July 11 and Aug. 21, I observed the following visitors:

Hymenoptera —*Apidæ.* (1) Apis mellifica L. ☿, h.; (2) Bombus separatus Cr. ♂ ♀ ☿, h.; (3) B. virginicus Oliv. ☿ h.: (4) B. americanorum F. ☿; (5) Apathus laboriosus F. ♀, h.; (6) Melissodes bimaculata Lep. ♂ ♀ h.t.; (7) Ceratina dupla Say ♀, h.c.p.; (8) Megachile brevis Say ♂ ♀. h.t.; (9) Heriades carinatum Cr.. ♀ p.: (10) Cœlioxys 8-dentata Say ♂, h.; (11) Epeolus lunatus Say ♂, h. *Andrenidæ*, (12) Halictus lerouxii Lep. ♂ ♀. h.c.t.; (13) H. fasciatus Nyl. ♂ ♀. h. (14) H. confusus Sm. ♀, p.; (15) H. stultus Cr. ♀; (16) H. albipennis Rob. ♂;

(17) Agapostemon radiatus Say ♀; (18) Sphecodes mandibularis Cr. ☿; (19) Prosopis affinis Sm. ♀, p. *Vespidæ*, (20) Polistes pallipes Lep. h. *Eumenidæ*, (21) Eumenes fraternus Say, h.c.t.; (22) Odynerus arvensis Sauss. h.; (23) O. foraminatus Sauss. h.; (24) O. anormis Say, h.t. *Crabronidæ*, (25) Crabro interruptus Lep.; (26) C. rufifemur Pack., h. p.; (27) Oxybelus frontalis Rob. *Philanthidæ*, (28) Cerceris sp., h.; (29) C. clypeata Dahlb., h.c.; (30) C. bicornuta Guér., h.; (31) C. compacta Cr., h.c.; (32) C. finitima Cr. *Bembecidæ*, (33) Bembex nubillipennis Cr., h. *Larridæ*, (34) Astata unicolor Say, h.; (35) Tachytes distinctus Sm., h.; (36) T. validus Cr., h.; (37) T. pepticus Say, h. *Sphecidæ*, (38) Ammophila intercepta Lep.; (39) Pelopœus cementarius Dru.; (40) Isodontia philadelphica Lep., h.; (41) Sphex ichneumonea L., h.; (42) S. pennsylvanica L., h.; (43) Priononyx thomæ F., h.; (44) P. atrata Lep. *Pompilidæ*, (45) Pompilus sp., h.; (46) Priocnemis terminatus Say. h.; (47) P. fulvicornis Cr., h. *Scoliidæ*, (48) Myzine sexcincta F., h.t.; (49) Scolia bicincta F., h. *Formicidæ*, (50) Phrenolepis sp. *Chrysididæ*, (51) Holopyga ventralis Say. *Tenthredinidæ*, (52) Hylotoma humeralis Beauv., h.

Diptera.—*Midasidæ*, (53) Midas clavatus Dru., h. *Bombylidæ*, (54) Systœchus vulgaris Lw. *Empidæ*, (55) Empis sp. *Conopidæ*, (56) Physocephala tibialis Say, h.; (57) Conops xanthopareus Will., h.; (58) C. brachyrrhynchus Macq. *Syrphidæ*, (59) Paragus bicolor F.; (60) Chrysogaster nitida Wied.; (61) Allograpta obliqua Say; (62) Mesograpta polita Say; (63) M. marginata Say; (64) Sphærophoria cylindrica Say; (65) Eristalis latifrons Lw., h.; (66) E. transversus, Wied.; (67) Tropidia quadrata Say, h.; (68) Syritta pipiens L., c. *Tachinidæ*, (69–72) spp., t.; (73) Hyalomyia purpurascens Towns.;* (74) Trichopoda pennipes F.; (75) Cistogaster divisa Lw.; (76) Ocyptera euchenor Walk., t.; (77) Wahlbergia arcuata Say, t.; (78) Jurinia apicifera Walk., h.; (79) Micropalpus sp., h.t.; (80) Exorista theclarum Scud.; (81) Mascicera sp.; (82) Eggeria? sp.; (83) Acroglossa hesperidarum Will., h.c.p.t. *Sarcophagidæ*, (84–87) Sarcophaga spp. *Muscidæ*, (88) sp.; (89) Lucilia sp.; (90) L. cæsar L., c.; (91) L. cornicina F., h.c.p.t.; (92) L. macellaria F., c.t. *Anthomyidæ*, (93) Anthomyia sp.; (94–5) Limnophora sp. *Sepsidæ*, (96) Sepsis sp.

Lepidoptera.—*Rhopalocera*, (97) Papilio cresphontes Cram.; (98) Pieris rapæ L., h.; (99) Colias philodice Godt.; (100) Danais archippus F., h.; (101) Argynnis cybele F.; (102) Phyciodes tharos Dru.; (103) Pyrameis atalanta L.; (104) Chrysophanus thoe Bd.-Lec.; (105) Lycæna comyntas Godt.; (106) Pamphila peckius Kby., h.; (107) P. cernes Bd.-Lec.; (108) P. verna Edw.; (109) Pholisora catullus F.; (110) P. hayhurstii Edw., h.; (111) Eudamus lycidas Sm.-Abb. *Pyralidæ*, (112) Scepsis fulvicollis Hübn.

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* Kindly named and described for me by Mr. C. H. Tyler Townsend, Nos. 76 and 77, determined by him.

Coleoptera. — *Scarabæidæ.* (113) Trichius piger F. *Cerambycidæ.* (114) Typocerus sinuatus Newm. *Rhipiphoridæ.* (115) Rhipiphorus limbatus F.

Of the 58 species bearing pollinia of this *Asclepias*, 52 have the corpuscula attached to the hairs of their legs or to the pulvilli, 10 have them on their claws, and 13 have them on their tongues.

Asclepias incarnata L. — The following visitors were taken on 24 days, between July 22 and Aug. 21 :

Hymenoptera. — *Apidæ*, (1) Apis mellifica L. ☿. h.t., ab., one dead; (2) Bombus virginicus Oliv. ♀ ☿, h.c.t.; (3) B. vagans Sm. ♄. h.c.t; (4) B. americanorum F. ♄ ♀ ☿. h.c.t.; (5) B. pennsylvanicus DeG. ♄ ♀ ☿. h.c.; (6) B. scutellaris Cr. ♄ ☿, h.c.t.; (7) B. separatus Cr. ♄ ♀ ☿. h.c., very ab.; (8) Entechnia taurea Say ♄. h.; (9) Megachile brevis Say ♄ ♀. *Andrenidæ*, (10) Colletes latitarsis Rob. ♀. h.c.t., dead; (11) Halictus coriaceus Sm. ♂. h.t.; (12) H. confusus Sm. ♄; (13) Augochlora pura Say ♄. t. *Vespidæ.* (14) Vespa sp., h.c.t.; (15) V. maculata L.; (16) V. germanica F., h.; (17) V. cuneata F., h.c.t.; (18) Polistes pallipes Lep., h.t.; (19) P. metricus Say, h.c.; (20) P. rubiginosus Lep., h.c. *Eumenidæ*, (21) Eumenes fraternus Say; (22) Odynerus arvensis Sauss., h.c.t. *Crabronidæ*, (23) Oxybelus packardii Rob., c. *Philanthidæ.* (24) Cerceris clypeata Dahlb., h.c.; (25) C. compacta Cr., h.c.; (26) C. bicornuta Guér. h.c.t.• *Nyssonidæ.* (27) Hoplisus rufoluteus Pack., h. *Bembecidæ*, (28) Megastizus brevipennis Walsh, h.; (29) Bembex fasciata F., h.; (30) B. nubillipennis Cr., h. *Larridæ*, (31) Tachytes sp., h.; (32) T. distinctus Sm., h.; (33) T. validus Cr., h.t.; (34) T. pepticus Say, h. *Sphecidæ.* (35) Pelopœus cementarius Dru., h., one dead; (36) Sphex ichneumonea L., h.; (37) S. pennsylvanica L., h.c.t.; (38) Priononyx atrata Lep., h.; (39) P. thomæ F., h. *Pompilidæ.* (40) Pompilus atrox Dahlb., h.; (41) Priocnemis fulvicornis Cr.; (42) P. unifasciatus Say, h.; (43) Agenia accepta Cr., h. *Scoliidæ*, (44) Myzine sexcincta F., h.c.t.; (45) M. interrupta Say, h.; (46) Scolia bicincta F., h.

Lepidoptera.—*Rhopalocera*, (47) Papilio philenor L., h.; (48) P. asterias F., h.c.; (49) P. troilus L., h.; (50) P. turnus L., h.; (51) P. cresphontes Cram., h.; (52) Pieris rapæ L., h.c.; (53) Colias philodice Godt., h.; (54) Danais archippus F., h.; (55) Argynnis idalia Dru., h.; (56) A. cybele F., h.; (57) Phyciodes tharos Dru.; (58) Pyrameis atalanta L., h.c.; (59) Limenitis disippus Godt., h.; (60) Libythea bachmanni Kirtl., h.; (61) Pamphila peckius Kby.; (62) P. cernes Bd.-Lec., h.; (63) P. verna Edw.; (64) Pholisora catullus F.; (65) Eudamus lycidas Sm.-Abb., h.; (66) E. tityrus F. *Pyralidæ*, (67) Scepsis fulvicollis Hübn.

Diptera. — *Midasidæ*, (68) Midas clavatus Dru., h. t. *Bombylidæ*, (69) Sparnopolius fulvus Wied. *Conopidæ*, (70) Conops xanthopareus Will., p.; (71) Physocephala tibialis Say. *Tachinidæ*, (72) sp.; (73) Cistogaster divisa Lw., t.; (74) Acroglossa hesperidarum Will.

Coleoptera. — *Lampyridæ*, (75) Chauliognathus pennsylvanicus DeG., h.c.t., ab. *Scarabæidæ*, (76) Euphoria sepulchralis F., h.c.t., ab.; (77) Trichius piger F., h.

Hemiptera. — *Lygæidæ*, (78) Lygæus fasciatus Dall., h.; (79) L. turcicus F.

Birds.—*Trochilidæ*, (80) Trochilus colubris L., s.; of course it cannot extract the pollinia.

The flowers are gnawed by two beetles: *Tetraopes tetraophthalmus* Forst. and *Epicauta vittata* F.

Of the 63 species bearing pollinia of *Asclepias incarnata*, 60 have the corpuscula on the hairs of their legs or on the pulvilli, 23 have them on their claws, and 20 have them attached to their tongues. Dead insects of three species (1, 10, 35) were found entrapped and killed by flowers.

Asclepias Cornuti Dec.—Observations on the insect visitors of this plant were made on 24 days, between June 21 and July 22. Among the insects which frequent the flowers there are many which are able to reach the nectar, but which, as a rule, do not extract the pollen at all, or run the risk of becoming hopelessly entangled and of losing their lives in consequence. Although an efficient visitor may sometimes be unable to free itself on account of all of its feet becoming entangled simultaneously, as in the case of the insects mentioned under *A. incarnata*, it is obvious that the flower can hardly be considered as adapted to insects which often lose their lives in this way. In a similar way all insects should be regarded as intruders which do not readily extract the pollinia, either on account of their small size, or their way of resting upon the flowers. From these considerations I place the visitors in separate groups.

The following insects were found dead upon the flowers:

Hymenoptera.—*Apidæ*, (1) Apis mellifica L. ☿, p.c.t.

Diptera.—*Tachinidæ*, (2) Acroglossa hesperidarum Will., p. *Sarcophagidæ*, (3) Sarcophaga sp., p. *Muscidæ*, (4) Lucilia cornicina F.; (5) Stomoxys calcitrans L. *Anthomyidæ*, (6) Anthomyia, sp.

Lepidoptera.—*Bombycidæ*, (7) Callimorpha fulvicosta* Clem., p. *Noctuidæ*, (8) Agrostis upsilon Rott.; (9) Drasteria erechtea* Cram., p.

It is a common thing to find dead hive-bees hanging to the flowers. It is evident, therefore, that, to effect the pollination of *A. Cornuti* with certainty, an insect must be larger or stronger than the hive-bee, or at least more able to free itself from the flowers.

The following visitors either do not extract the pollinia at all, or could hardly be expected to transfer the pollinia to any great extent without danger of losing their lives:

Hymenoptera.—*Apidæ*, (10) Megachile brevis Say ♀; (11) Cœlioxys 8-dentata Say ♂ ♀, c. *Andrenidæ*, (12) Augochlora lucidula Sm. ♀; (13) Halictus fasciatus Nyl. ♀, c. *Philanthidæ*, (14) Cerceris clypeata Dahlb.

Diptera.—*Stratiomyidæ*, (15) Odontomyia cincta Oliv. *Bombylidæ*. (16) Hemipenthes sinuosa Wied. *Conopidæ*, (17) Stylogaster biannulata Say. *Syrphidæ*, (18) Eristalis dimidiatus Wied., p.t.; (19) Tropidia mamillata Lw., p.; (20) T. quadrata Say, h.; (21) Syritta pipiens L., p. *Tachinidæ*. (22) Trichopoda trifasciata Lw.. p.t.; (23) Cistogaster divisa Lw.; (24) Jurinia apicifera Walk., p.; (25) Micropalpus sp.; (26) Frontina sp., p. *Anthomyidæ*, (27) Limnophora sp., p.

Lepidoptera.—*Rhopalocera*, (28) Thecla calanus Hübn.; (29) Chrysophanus thoe Bd.-Lec.; (30) Pamphila peckius Kby.; (31) P. cernes Bd.-Lec.; (32) P. dion Edw.; (33) Pholisora catullus F. *Sphingidæ*, (34) Chærocampa tersa L., h. *Pyralidæ*, (35) Scepsis fulvicollis Hübn., h.; (36) Eurycreon rantalis Guen.

Coleoptera.—*Lampyridæ*. (37) Photinus pyralis L.. h.

Hemiptera.—*Lygæidæ*. (38) Lygæus fasciatus Dall.. h.; (39) L. turcicus F., h.c. *Pentatomidæ*, (40) Euschistus variolaris P.B.. h.; (41) Podisus spinosus Dall., p., frequents the flowers for entangled insects.

The following visitors may be expected to transfer the pollinia without difficulty:

Hymenoptera.—*Apidæ*, (42) Bombus separatus Cr. ♀ ☿, t.: (43) B. pennsylvanicus DeG. ☿; (44) B. americanorum F. ♀; (45) Melissodes obliqua Say ♂, p. *Eumenidæ*. (46) Odynerus arvensis Sauss., h. *Philanthidæ*, (47) Cerceris bicornuta Guér., h. *Bembecidæ*, (48) Bembex nubillipennis Cr., h. *Sphecidæ*. (49) Pelopœus cementarius. Dru.; (50) Sphex ichneumonea L., h.; (51) Priononyx atrata Lep., p.; (52) P. thomæ F., h. *Scoliidæ*, (53) Myzine sexcincta F., h.; (54) Scolia bicincta F., h.

* Kindly determined for me by Prof. G. H. French.

Lepidoptera. — *Rhopalocera*, (55) Papilio philenor L.; (56) P. asterias F,; (57) Colias philodice Godt.; (58) Danais archippus F., h.; (59) Argynnis idalia Dru.; (60) A. cybele F., h.; (61) Grapta interrogationis F., h.t.; (62) Vanessa antiopa L., h.c.; (63) Pyrameis atalanta L., h.; (64) Limenitis disippus Godt.; (65) Eudamus lycidas Sm.-Abb., h.; (66) E. tityrus F.

Diptera.—*Midasidæ*, (67) Midas clavatus Dru., t.

Coleoptera.—*Scarabæidæ*, (68) Trichius piger F.

I have also found these beetles gnawing the flowers: *Melanotus communis* Gyll., *Macrodactylus angustatus* Bv., and *Tetraopes tetraophthalmus* Forst.; plants growing in my yard were freed from the latter pest by the rose-breasted grossbeak, *Habia ludoviciana*.

Of the 39 species bearing pollinia of this *Asclepias*, 20 have the corpuscula on the hairs of their legs, 15 have them on their pulvilli, 6 have corpuscula attached to their tongues, and 5 have them attached to their claws.

Asclepias Sullivantii Engelm. — The insect visitors of this plant were observed on 25 days, between June 22 and Aug. 20. The anther wings are much longer and stronger than in *A. Cornuti*, and the hoods are deeper. Accordingly, the number of insects which can pollinate the flower with safety is not so great.

Insects of the following species were found dead on the flowers; they must, therefore, be regarded as not adapted to the flowers, although some of them may sometimes effect pollination:

Hymenoptera. — *Apidæ*, (1) Apis mellifica L. ☿, and one ♂, c.p.t.; (2) Xenoglossa pruinosa Say ♂, c., one; (3) Megachile infragilis Cr. ♂, c., one: (4) M. brevis Say ♂ ♀, c. *Andrenidæ*, (5) Halictus lerouxii Lep. ♂, p.c.; (6) H. ligatus Say ♂, c.; (7) H. fasciatus Nyl. ♂, c. *Larridæ*, (8) Astata unicolor Say, one. *Sphecidæ*, (9) Isodontia philadelphica Lep., h.c., one.

Diptera. — *Bombylidæ*, (10) Sparnopolius fulvus Wied., one. *Syrphidæ*, (11) Eristalis æneus F., c., one; (12) Syritta pipiens L., one. *Muscidæ*, (13) Lucilia cornicina F.

Lepidoptera.—*Rhopalocera*, (14) Pamphila peckius Kby., p. *Pyralidæ*. (15) Scepsis fulvicollis Hübn.

Coleoptera.—*Scarabæidæ*. (16) Trichius piger F,, c.

This list plainly indicates that only the largest insects are adapted to transfer the pollen of this *Asclepias*.

The following insects either do not extract the pollinia at all, or could not be expected to do so often :

Hymenoptera.—*Apidæ*, (17) Ceratina dupla Say; (18) Megachile relativa Cr. ♀, p.c., one; (19) Cœlioxys 8-dentata Say ♂♀. *Andrenidæ*, (20) Augochlora pura Say ♄ ♀; (21) A. labrosa Say ♂♀; (22) A. lucidula Sm. ♀; (23) Sphecodes arvensis Patton. *Eumenidæ*, (24) Odynerus arvensis Sauss. *Crabronidæ*, (25) Crabro rufifemur Pack.. one. *Philanthidæ*, (26) Cerceris clypeata Dahlb. *Larridæ*, (27) Lyroda subita Say. *Scoliidæ*, (28) Myzine sexcincta F. *Ichneumonidæ*, (29) Ichneumon flavizonatus Cr., one, with corpusculum on antenna!

Diptera.—*Syrphidæ*, (30) Tropidia quadrata Say. *Tachinidæ*, (31) Micropalpus sp.; (32) Frontina sp.

Lepidoptera.—*Rhopalocera*, (33) Phyciodes tharos Dru.; (34) Thecla humuli Harr.; (35) T. titus F., h., one; (36) Chrysophanus thoe. Bd.-Lec.; (37) Lycæna comyntas Godt.; (38) Pamphila cernes Bd.-Lec. *Ægeriadæ*, (39) Ægeria æmula Hy. Edw.

The following visitors seem to me to be the only ones adapted to the flower :

Hymenoptera.—*Apidæ*, (40) Bombus separatus Cr. ♀ ☿, sp.c.; (41) B. pennsylvanicus DeG. ♄ ☿, sp., p.c. t.; (42) B. scutellaris Cr. ☿. *Bembecidæ*, (43) Bembex nubillipennis Cr., c. *Sphecidæ*, (44) Pelopœus cementarius Dru., c.; (45) Priononyx thomæ F., h.

Lepidoptera.—*Rhopalocera*, (46) Papilio asterias F., c.; (47) Colias philodice Godt., c.; (48) Danais archippus F., sp., h.c.; (49) Argynnis cybele F.; (50) Pyrameis atalanta, L.

Finally, the structure of the hoods seem to indicate an adaptation to bumble-bees, and I suspect that before the appearance of the hive-bee the flowers depended mainly upon *Bombus separatus*.

I have also seen the flowers visited by the ruby-throated humming-bird. *Podisus spinosus* Dall. frequents the flowers to prey upon entangled insects.

Of the 22 species of insects bearing corpuscula of this *Asclepias*, 18 have the corpuscula attached to their claws, 4 have them on the hairs of their legs, 5 have them on their pulvilli, 3 bear them on their tibial spurs, 2 have corpuscula on their tongues, and 1, by accident, has a corpusculum attached to the tip of its antenna.

Asclepias tuberosa L.—The following visitors were taken on this butterfly flower :

Lepidoptera.—*Rhopalocera*, (1) Papilio philenor L., h.; (2) P. aste-

rias F., h.; (3) P. troilus L., h.; (4) Pieris protodice Bd.-Lec., h.; (5) Colias philodice Godt., h., (6) Danais archippus F.; (7) Argynnis idalia Dru., h.; (8) A. cybele F., h.; (9) Phyciodes tharos Dru.; (10) Thecla titus F.; (11) Chrysophanus thoe Bd.-Lec.; (12) Lycæna comyntas Godt. *Pyralidæ*, (13) Scepsis fulvicollis Hübn., h.

Hymenoptera.—*Apidæ*, (14) Apis mellifica L. ☿, h.; (15) Megachile brevis Say ♂ ♀; (16) M. montivaga Cr. ♀; (17) Cœlioxys 8-dentata Say ♀, h.c. *Andrenidæ*, (18) Augochlora humeralis Patton ♀, c. *Sphecidæ*, (19) Ammophila intercepta Lep., h.; (20) Sphex ichneumonea L. h.; (21) Priononyx thomæ F., h.; (22) P. atrata Lep.

Diptera.—*Tachinidæ*, (23) Acroglossa hesperidarum Will., h.

I have also seen the flowers visited by the ruby-throated humming-bird, *Trochilus colubris* L.

Of the 15 species bearing pollinia of this plant, 14 have corpuscula fastened to the hairs of their legs, 2 have them on their claws.

Asclepias purpurascens L.— This is also a butterfly-flower. I have found it visited by the following insects:

Lepidoptera.—*Rhopalocera*, (1) Papilio philenor L.; (2) P. cresphontes Cram.; (3) Colias philodice Godt.; (4) Danais archippus F.; (5) Argynnis idalia Dru., h.; (6) A. cybele F., h.; (7) Melitæa phæton Dru., h.; (8) Pyrameis atalanta L., h.; (9) Thecla acadica Edw.; (10) T. calanus Hübn.; (11) Chrysophanus thoe Bd.-Lec.; (12) Lycæna comyntas Godt.; (13) Pamphila zabulon Bd.-Lec.; (14) P. peckius Kby.; (15) P. cernes Bd.-Lec.; (16) P. verna Edw.; (17) P. manataaqua Scud.; (18) Eudamus pylades Scud., h.

Hymenoptera.—*Apidæ*, (19) Apis mellifica L. ☿, h.; (20) Bombus separatus Cr. ♀; (21) B. vagans Sm. ♀; (22) B. americanorum F. ♀; (23) Anthophora abrupta Say ♂ ♀. *Andrenidæ*, (24) Augochlora pura Say ♀; (25) Halictus confusus Sm. ♀. *Sphecidæ*, (26) Priononyx atrata, Lep.

Diptera.—*Tachinidæ*, (27) Acroglossa hesperidum Will., h.

Hemiptera.—*Lygæidæ*, (28) Lygæus fasciatus Dall., h.

The flowers are also visited for honey by the humming-bird, *Trochilus colubris* L., and are gnawed by *Tetraopes tetraophthalmus*.

The 8 species of insects bearing pollinia of this *Asclepias* have the corpuscula attached only to their tarsal hairs.

Acerates longifolia Ell.—The list of visitors was observed on 19 days, between July 5 and Aug. 1. The names of the insects are followed by f., l., t., or v.s., according as the corpuscula

were found attached to the hairs of the face, labrum, tongue, or ventral surface.

Hymenoptera.—*Apidæ*, (1) Apis mellifica L. ☿, v.s.; (2) Bombus separatus Cr. ♂ ♀ ☿, ab., l., t.. v.s.; (3) B. scutellaris Cr. ☿. ab.. v.s.; (4) Megachile brevis Say ♀; (5) M. mendica Cr. ♀, v.s. *Vespidæ*. (6) Polistes pallipes Lep. *Eumenidæ*, (7) Odynerus arvensis Sauss. *Philanthidæ*, (8) Cerceris bicornuta Guér., f., t., v.s.; (9) C. compar Cr. *Bembecidæ*, (10) Bembex nubillipennis Cr.. ab.. l. *Sphecidæ*, (11) Prionyx atrata Lep., v.s. *Pompilidæ*, (12) Priocnemis unifasciatus Say, t., v.s.: *Scoliidæ*, (13) Myzine sexcincta F.

Coleoptera.—*Scarabæidæ*, (14) Trichius piger F.. v.s.

Lepidoptera.—*Rhopalocera*, (15) Thecla sp.; (16) Chrysophanus thoe Bd.-Lec. *Pyralidæ*, (17) Scepsis fulvicollis Hübn.

GENTIANACEÆ.

Gentiana Andrewsii Griseb.*—The flowers are proterandrous. They remain closed, so that only the largest and most intelligent bees can open them. The stamens are united with the corolla tube, and their free ends bend over upon the pistil. To reach the nectar the bee's tongue must be thrust between the filaments and must be 15 or 16 mm. long. The flower is visited abundantly by *Bombus americanorum* F. ♂ ♀ ☿.

There is no doubt that flowers were originally of such a form that almost any insects could enter them and reach the nectar. Many have narrowed the entrance by the development of tufts of hair, or of processes like the palates of personate flowers, until all insects were excluded except bees. These have kept on visiting the flowers until now they enter completely closed flowers like those of *Linaria*.

They seem to have been trained to bad habits in this way, for they sometimes force their way into flowers which are not yet ready to receive them. I have mentioned the case of *Bombus vagans* forcing her way into the closed buds of *Triosteum perfoliatum*, and *B. americanorum* does the same in the case of buds of *Linaria vulgaris*. Mr. Pammel refers to a number of cases in which flower-buds have been opened or perforated by insects.† The irregular behavior in such cases is not to be laid

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* See Beal, Am. Nat. viii. 180, and Vausenburg, ibid. ix. 310.

† On the Perforation of Flowers, Trans. St. L. Acad. Sci. v. 255, note.

to the blame of the insects, but to the flower itself, which secretes its nectar prematurely.

A habit on the part of the visitor of forcing its way into a flower before it is fairly open might result in a form like the present, especially when a set of intruders might be excluded without interfering with the proper visitors.

POLEMONIACEÆ.

Phlox divaricata L.—The narrow tubes are about 14 or 15 mm. long. The flowers are adapted to lepidoptera, but are sometimes visited by long-tongued bees. On 11 days, between April 26 and May 19, I observed the following visitors:

Hymenoptera.—*Apidæ*, (1) Bombus virginicus Oliv. ♀; (2) B. vagans Sm. ♀; (3) B. americanorum F. ♀; (4) Synhalonia speciosa Cr. ♀.

Lepidoptera.—*Rhopalocera*, (5) Danais archippus F.; (6) Papilio philenor L.; (7) P. asterias F.; (8) P. troilus L.; (9) P. turnus L.; (10) Colias philodice Godt.; (11) Pamphila zabulon Bd.-Lec. vars. hobomok Harr. & quadraquina Scud.; (12) Nisoniades icelus Lintn.; (13) Eudamus bathyllus Sm.-Abb. *Sphingidæ*, (14) Hemaris thysbe F.; (15) Deilephila lineata F.

Polemonium reptans L.—The flowers are proterandrous as in *P. cæruleum*,* which it resembles in most respects. The upper part of the tube has a few purplish lines which serve as pathfinders. The flowers commonly turn to one side, so that insects land upon the stamens and prefer to insert their tongues between the upper ones. The upper stamens are a little shorter; consequently, their anthers do not come in the way of the lower ones when a bee rests upon them.

In the Alps, Müller found *P. cæruleum* visited by workers of 5 species of *Bombus*, but I have never seen a *Bombus* worker flying while *P. reptans* was in bloom. In low Germany bumblebees were not observed among the visitors of *P. cæruleum*.

On 6 days, between April 20 and May 7, I observed the following visitors:

Hymenoptera.—*Apidæ*, (1) Apis mellifica L. ☿, s. & c.p.†; (2) Bombus americanorum F. ♀, s., ab.; (3) B. vagans Sm. ♀, s.; (4) Synhalonia

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* For references see Müller: Fertilization of Flowers, 407.

† ♂, male; ♀, female; ☿, worker; s, sucking; c.p., collecting pollen; f.p., feeding on pollen; ab., abundant.

honesta Cr. ♀, s.; (5) Alcidamea producta Cr. ♂, s.; (6) Osmia albiventris Cr. ♀, s. & c.p.; (7) Nomada luteola Lep. ♂, s. *Andrenidæ*, (8) Augochlora pura Say ♀, s. & c.p.; (9) Andrena, sp. ☿, s.; (10) A. sayi Rob. ♀, c.p.; (11) A. polemonii Rob. ☿ ♀, s. & c.p.; (12) Halictus pilosus Sm. ♀, s. & c.p.

Diptera.—*Syrphidæ*, (13) Mesograpta marginata Say, f.p.; (14) Rhingia nasica Say, s. & f.p.

Lepidoptera.—*Rhopalocera*, (15) Colias philodice Godt., s.; (16) Nisoniades brizo Bd.-Lec., s.

Coleoptera.—*Coccinellidæ*, (17) Megilla maculata DeG., f.p.

HYDROPHYLLACEÆ.

*Hydrophyllum Virginicum** L.—The flowers are male in the first stage. The stigma, when receptive, surpasses the anthers. On account of the erect corolla lobes and the hairy filaments, the nectar can be obtained most conveniently by a tongue about 9 mm. long.

May 11, 12, 21 and 23 I observed the following visitors:

Hymenoptera.—*Apidæ*, (1) Bombus virginicus Oliv. ♀; (2) B. ridingsii Cr. ♀, ab.; (3) B. vagans Sm. ♀; (4) B. americanorum F. ♀; (5) Anthophora abrupta Say ♀—all s. *Andrenidæ*, (6) Augochlora pura Say ♀, c.p.

Diptera.—*Syrphidæ*, (7) Rhingia nasica Say, f.p.

Hydrophyllum appendiculatum Michx.—The flowers are proterandrous as in the preceding. They are pale blue with white centres. The throat is more widely open than in *H. Virginicum*, and the filaments are not hairy. There is, therefore, less difficulty in reaching the nectar. Accordingly, we find more short tongues, although bumble-bees remain by far the most numerous guests. The flowers and flower-clusters are much more conspicuous, and the plants grow in larger patches.

May 3, 14 and 16 I observed the following visitors:

Hymenoptera.—*Apidæ*, (1) Apis mellifica L. ☿, s. & c.p., ab.; (2) Bombus virginicus Oliv. ♀ ☿, s.; (3) B. separatus Cr. ♀ ☿, s. & c.p., ab.; (4) B. ridingsii Cr. ♀ ☿, s. & c.p., ab.; (5) B. vagans Sm. ♀, s.; (6) B. americanorum F. ♀, s., ab.; (7) Synhalonia honesta Cr. ☿ ♀, s. & c.p., ab.; (8) S. speciosa Cr. ☿, s.; (9) Megachile brevis Say ♂, s., once; (10) Osmia lignaria Say ♀, s., ab.; (11) O. albiventris Cr. ♀, s. & c.p., ab. *Andrenidæ*, (12) Andrena erigeniæ Rob. ♂ ♀, s. & c.p.;

* See Sprengel, "Das entdeckte Geheimniss," 104, Tab. xix. 46 & 47.

(13) Agapostemon radiatus Say ♀, s. & c.p.; (14) Augochlora pura Say ♀, s. & c.p.. ab.; (15) A. lucidula Sm. ♀. s., once; (16) Halictus 4-maculatus Rob. ♀, s.. once; (17) H. pectoralis Sm. ♀, s.; (18) H. coriaceus Sm. ♀, s., ab.; (19) H. pilosus Sm. ♀. s., once; (20) H. confusus Sm. ♀, s., once. *Eumenidæ*, (21) Odynerus tigris Sauss., s.; (22) O. foraminatus Sauss.. s.

Diptera.—*Empidæ*, (23) Empisnuda Lw.. s., ab. *Syrphidæ*. (24) Rhingia nasica Say, s. & f.p., ab.; (25) Eristalis flavipes Walk., s.; (26) Criorhina intersistens Walk., s.; (27) Xylota chalybea Wied. *Anthomyidæ*. (28) Anthomyia sp.

Lepidoptera.—*Rhopalocera*, (29) Phyciodes nycteis D. & H.; (30) Pamphila zabulon Bd.-Lec.; (31) Pholisora hayhurstii Edw.—all s.

BORRAGINACEÆ.

Mertensia Virginica DC.—I have found the flowers open on four or five successive days. On the morning of the first day the anthers are still closed, while the stigma appears receptive. On the second day, and sometimes on the third, the anthers discharge their pollen. Then the flowers hang on for a day or two, adding to the conspicuousness of the inflorescence. The flowers are hardly to be regarded as proterogynous, cross-fertilization being secured by the stigma being widely separated from the anthers and striking the bee in advance of them.

Nectar is secreted by four glands alternating with the carpels. The style is somewhat flattened at base, and the carpels are in pairs on each side of it. In the wider intervals thus formed, two of the glands are situated, and are much larger than the others, rising as high as the carpels.

The bell-shaped border opens into a tube which is from 14 to 15 mm. long. The blue color and the size of the tube, together with the pendulous position of the flowers, indicate an adaptation to the larger bees, but butterflies sometimes hang on the flowers aud draw out their honey. In the following list all of the insects are intruders except *Bombus*, *Anthophora*, and *Synhalonia*.

On 16 days, between April 19 and May 13, I observed the following visitors:

Hymenoptera.—*Apidæ*, (1) Apis mellifica L. ☿, c.p.; (2) Bombus separatus Cr. ♀, s.; (3) B. ridingsii Cr. ♀, s.; (4) B. vagans Sm. ♀, s.; (5) B. americanorum F. ♀. s.; (6) B. pennsylvanicus DeG. ♀, s.; (7) Anthophora abrupta Say ♂♀, s.; (8) A. ursina Cr. ♂♀. s.; (9)

Synhalonia speciosa Cr. ☿♀, s.; (10) S. honesta Cr. ♀, s.; (11) S. atriventris Sm. ♂, s.; (12) Osmia albiventris Cr. ♀, c.p. *Andrenidæ*. (13) Augochlora pura Say ♀; (14) Halictus confusus Sm. ♀—both crawling into tube.

Lepidoptera.—*Rhopalocera*, (15) Danais archippus F.; (16) Pyrameis atalanta L.; (17) Papilio troilus L.; (18) Nisoniades juvenalis F.—all s. *Sphingidæ*, (19) Hemaris thysbe F., s.

Diptera.—*Bombylidæ*, (20) Bombylius fratellus Weid., s. *Syrphidæ*, (21) Rhingia nasica Say, s. & f.p.; (22) Teuchocnemis literatus Lw., f.p.

According to Schneck,* this flower is perforated by a bumble-bee—either *B. americanorum* or *B. pennsylvanicus*. Only female bumble-bees fly while *Mertensia* blooms, and, since the females of both of these bees can easily drain deeper flowers, I see no reason why they should make holes in this flower.

Xylocopa
Bot. Gaz. XVI, 312

CONVOLVULACEÆ.

Ipomœa pandurata Meyer.—Insects can crawl into the tube of the corolla as far as three centimetres. The nectar, which is secreted by a fleshy disc surrounding the base of the ovary, is concealed by the broad, hairy bases of the filaments, between which bees must insert their proboscides. The stamens are of unequal length, so that some of the anthers reach beyond the stigma.

The flowers are very large and white, with purple in the bottom of the tube. A proboscis 14 mm. long can reach all of the nectar. The flower is visited mainly by a remarkable assemblage of bees of characteristic American genera. The following were observed on eight days, between July 11 and Aug. 26:

Apidæ, (1) Bombus separatus Cr. ♂, s.; (2) B. americanorum F. ♀ ☿, s.; (3) Entechnia taurea Say ♂♀, s., ab.; (4) Emphor bombiformis Cr. ♂, s., one; (5) Xenoglossa ipomϾ Rob. ♂♀, s., ab.; (6) X. pruinosa Say ♂♀, s., ab.; (7) Melissodes bimaculata Lep. ♂♀, s. & c.p., ab.

Convolvulus sepium L.—In Europe the distribution and fertility of this plant is supposed to have some relation to the distribution of *Sphinx convolvuli*,† though Müller has found it visited by other insects by day.

On 3 days, between June 29 and July 27, I found it visited in sunlight by the following insects:

Apidæ.—(1) Bombus americanorum F. ♀ ☿, s., ab.; (2) Anthophora abrupta Say ♀, s.; (3) Entechnia taurea Say ♂, s.; (4) Melissodes bimaculata Lep. ♂, s.; (5) Ceratina dupla Say ♀, s.

* Bot. Gazette, xii. 111; xiii. 39.

† Fertilization of Flowers, 424.

SOLANACEÆ.

Solanum nigrum L.—The flowers are specially adapted to bumble-bee females, which visit them only to collect pollen, which they milk out of the apical chinks of the anthers with their jaws, as in the case of *Cassia*. Sprengel saw bees and bumble-bees collecting pollen. Müller saw *Melithreptus* (=Sphærophoria) *scriptus* and *Syritta pipiens* feeding on the pollen. The visits of these *Syrphidæ*, I think, have little significance, since they often visit flowers to which they are not adapted in order to feed upon stray pollen. In Florida, Feb'y 24, 1887, I saw *Bombus virginicus* Oliv. ♀ collecting the pollen. In Illinois I saw the flowers visited by *Bombus virginicus* ☿ and by *B. americanorum* F. ♀.

Solanum Carolinense L.— Like the preceding, this flower is adapted to bumble-bee females, which visit it only for pollen. I have seen *Bombus americanorum* F. ☿ collecting the pollen.

*Datura Tatula** L.—("Adv. from trop. Amer.") The flower measures about 11 centimetres. The stamens are adherent to the corolla tube for about 40 mm., after which they extend inward to the middle, so that bees are excluded from the honey and only *Sphingidæ* can reach it. I have seen *Deilephila lineata* F. sucking.

Hive-bees squeeze into the flower-buds as soon as they begin to open, and collect all of the pollen before the time of flight of hawk-moths. I have seen most of the pollen carried away as early as five o'clock in the afternoon. I have seen the following insects visiting the flower for pollen:

Hymenoptera.—*Apidæ*. (1) Apis mellifica F. ☿, ab.; (2) Melissodes perplexa Cr. ♀. *Andrenidæ*, (3) Halictus confusus Sm. ♀—all c.p.

Diptera. — *Syrphidæ*. (4) Syrphus ribesii L.; (5) Allograpta obliqua Say; (6) Mesograpta marginata Say; (7) Rhingia nasica Say—all f.p.

Coleoptera.—*Chryosmelidæ*. (8) Diabrotica 12-punctata Oliv., f.p.

Of course all of the insects mentioned above, except the *Deilephila*, must be regarded as intruders. The plant probably depends mainly upon self-fertilization and has spread beyond the range of its principal pollinators. The above-mentioned insects may aid in self-fertilization or cross-fertilization, but their visits only result from the flower opening prematurely.

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* On *D. Stramonium* see Sprengel, 122, and Schulz. Beiträge zur Kenntniss der Bestäubungseinrichtungen u. d. Geschlechtevertheilung b. d. Pflanzen, 73.

SCROPHULARIACEÆ.

Verbascum Thapsus L.– ("Nat. from Eur.")—In a paper on "Zygomorphy and its Causes."* I have assumed that when the perianth of lateral flowers failed to protect the stamens, either on account of its shortness or its wide expansion, insects would alight upon the stamens in preference to other parts of the flower, and in this way I endeavored to explain the origin of flowers which dust the visitor upon the ventral surface. It was my desire to discuss the irregularity of *Verbascum* in connection with that of *Scrophularia*, but I could not venture to do so because I had made no direct observations upon it, and because the observations which had been made by Müller did not clearly conform with my views. I have also criticised Prof. Henslow† for claiming that *Verbascum* is in the first stage of irregularity, but I was not then prepared to assert that the quotation which he made from Müller did not describe the true relations which visiting insects hold to different parts of the flower. Indeed, my statements rest upon the observation of *V. Thapsus* and *Blattaria* alone, and upon inferences drawn from Müller's lists.

I suppose the prototype of *Verbascum* to have been a bilabiate flower with didynamous stamens, because the type of the order is didynamous and because the two genera which with *Verbascum* form the tribe *Verbasceæ* have only four stamens. The flower was originally adapted to long-tongued bees which visited it for nectar, alighting upon the lower lip and striking their backs against the anthers. The stamens were included, holding their anthers against the upper wall of the corolla in such a position that flies and small bees would hardly be able to get at the pollen. Then the flower became more widely expanded, exposing the stamens so that the insects could easily alight upon them and eat or collect the pollen. The fifth stamen, being no longer crowded in the upper part of a narrow tube, regained its antheriferous function and joined the other four in their new position on the lower side. Then the flower, being fertilized mainly by insects coming for pollen, began to reduce its nectar supply.

* Bot. Gazette xiii. 146, 203, 224.

† Bot. Gazette xiii. 324; xiv. 134-36. And Henslow: Origin of Floral Strnctures, 118.

The quotation which Henslow makes from Müller* is in regard to *V. nigrum* and reads as follows: "The short tube widens out into a flat, five-lobed limb, which takes up an almost vertical position: the inferior lobe is the longest, and the two superior are shorter than the lateral lobes, so that an insect settles most conveniently upon the inferior. The stamens project almost horizontally," etc. From the relative positions of the limb and stamens, one would expect insects to prefer the latter as a resting-place. For some time Müller supposed *V. nigrum* contained no honey, but he afterwards found it. Of the visitors which he observed, 3 came for honey, 6 for pollen, and 1 for both honey and pollen; so that most of them were after pollen, and would most probably alight directly upon the stamens. Of 6 visitors of *V. phœnicium*, 5 were in search of pollen, and 1 vainly sought for nectar. Of 10 visitors of *V. Thapsus*, 7 were after pollen, and 3 "semeed to be sucking." Of 15 guests observed by me on *V. Thapsus*, all visited the flower exclusively for pollen, and invariably settled upon the stamens.

There seems, therefore, to be no reason for supposing, as Henslow does, that *Verbascum* is in the first stage of irregularity, and that insects use the lower lobes of the corolla as a landing-place. By exposing its stamens, the flower has changed from *nototribe* to *sternotribe*, from dusting its visitors upon their backs to dusting them upon the ventral surface. In this connection it may be well to mention that Delpino† has pointed out that *Verbascum* is adapted to pollen-collecting bees, and that the hairs upon the stamens are for the bees to cling to when gathering pollen.

The following visitors were observed on 6 days, between June 27 and July 9:

Hymenoptera.—*Apidæ* (1) Apis mellifica L. ☿,; (2) Bombus americanorum F. ☿. *Andrenidæ.* (3) Agapostemon nigricornis F. ♀; (4) Augochlora lucidula Sm. ♀; (5) Halictus pectoralis Sm. ♀ (6) H. coriaceus Sm. ♀; (7) H. confusus Sm. ♀: (8) H. cressonii Rob. ♀—all c.p.

Diptera.—*Syrphidæ*, (9) Pipiza pistica Will.: (10) *Syrphus americanus* Wied.; (11) Allograpta obliqua Say; (12) Mesograpta marginata Say; (13) M. geminata Say; (14) Syritta pipiens L.—all f.p. *Anthomyidæ*, (15) Anthomyia sp., f.p.

* Fertilization of Flowers, 429.

† Ulteriori osservazioni.

Linaria vulgaris Mill.* ("Nat. from Eu.")—That the flower is adapted to long-tongued bees is not only indicated by the size of the tube and the length of the spur, but by the fact that only the larger bees are able to open the flower with ease. I have seen a large bee, *Bombus americanorum*, visit 62 flowers in five minutes. When a bumble-bee alights upon the palate, its weight opens the flower, and all it has to do is to enter. But the other bees observed by me are not heavy enough to open the flower by their own weight, and so can only enter by squeezing in between the lips. Thus, I have seen the hive-bee enter so as to strike the stamens with its ventral surface or with its side, although it often brings its back against them. *Megachile brevis* ♀ goes into the flower upside down, but she may do so intentionally, so as to bring her ventral scopa in contact with the anthers, as she is in the habit of doing on many flowers which are adapted to dust their visitors upon the back.

Müller observed bees only on the flowers, but I have seen four butterflies stealing honey. They insert their thin proboscides between the closed lips with very little chance of touching the anthers or stigma. In the next species the tube is so contracted that butterflies can be utilized for transferring pollen. I regard all of the visitors of *L. vulgaris* as intruders, except *Bombus*.

On 8 days, between June 25 and Oct. 10, I observed the following visitors:

Hymenoptera.—*Apidæ*, (1) Apis mellifica L. ☿, s. & c.p.; (2) Bombus vagans Sm. ☿, s.; (3) B. americanorum F. ♂♀☿, s. & c.p., ab.; (4) B. virginicus Oliv. ☿, s. & c.p., one; (5) Megachile brevis Say ♀, c.p.: (6) Alcidamea producta Cr. ♀, s. and sometimes c.p., when it reverses to bring ventral scopa against anthers. *Andrenidæ*, (7) Agapostemon nigricornis F. ♀, s., one.

Lepidoptera.—*Rhopalocera*, (8) Pyrameis cardui L.; (9) Pieris rapæ L.: (10) Colias philodice Godt.; (11) Pamphila cernes Bd.-Lec.—all s.

Linaria Canadensis Spreng.—I have given some account of this plant, comparing it with other species of the genus.† The tubular portion of the corolla is contracted so that bees cannot enter as in *L. vulgaris*, and the nectar is thus comparatively

* See Müller. Fertilization of Flowers, 431.

† Bot. Gazette, xiii. 228.

more deeply concealed. The tube measures about 3 mm. and the spur about 6 mm., so that a long tongue is necessary to drain it. The spur is very slender—a character which favors butterflies, which are the most abundant visitors. Small bees can reach some of the nectar. On account of the weakness of the palate, flies sometimes suck up the honey, or feed upon the pollen.

At Orlando, Fla., the following visitors were observed on 7 days, between Feb. 17 and March 20:

Hymenoptera.—*Apidæ*, (1) Apis mellifica L. ☿; (2) Megachile brevis Say ♂♀: (3) Anthidium perplexum Sm. ♂; (4) Nomada torrida Sm. ♀. *Andrenidæ*, (5) Agapostemon aëruginosus Sm. ♀; (6) Augochlora sumptuosa Sm. ♀; (7) A. lucidula Sm. ♀: (8) Halictus pectoralis Sm. ♀: (9) H. capitosus Sm. ♀; (10) H. creberrimus Sm. ♀. *Scoliidæ*, (11) Elis 4-notata F. ♂♀—all s.

Lepidoptera.—*Rhopalocera*, (12) Phyciodes tharos Dru.; (13) Pyrameis huntera F.; (14) Junonia cœnia Hübn.; (15) Calephelis cænius L.; (16) Papilio philenor L.; (17) P. ajax L.; (18) Callidryas eubule L. (19) Terias lisa Bd.-Lec. (20) Pamphila eufala Edw.; (21) P. huron Edw.; (22) P. brettus Bd.-Lec.; (23) P. cernes Bd.-Lec.; (24) Eudamus sp. *Bombycidæ*. (25) Utetheisa bella L.—all s.

Diptera.—*Bombylidæ*, (26) Toxophora amphitea Walk., s. *Syrphidæ*, (27) Mesograpta marginata Say; (28) Baccha clavata F. (=B. babista Walk.)—both f.p.

Scrophularia nodosa L., var. *Marilandica* Gray.—In the Torrey Bulletin, viii. 133–140, Prof. Trelease has given a complete account of the fertilization of *Scrophularia* with references to the special literature.*

The flower is interesting on account of its special adaptation to wasps. Müller found it visited by 12 species of insects, of which 6 were *Vespidæ* and 6 bees.† I have found it visited by 14 species of bees, 11 *Vespidæ* and *Eumenidæ*, and 8 species of other families. Although more bees were observed on the flowers, the proportion of wasps is remarkable. I have found as many species on other plants, but never in such proportions. Indeed, I have taken 15 species of *Vespidæ* and *Eumenidæ* on flowers of *Cicuta maculata*, but the total number of hymenoptera was 143. Again, I took 14 species on *Pastinaca sativa*, but with 113 other

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* See also T. W. Fulton, Gardener's Chronicle, Jan. 2, 1886; and Foerste, Bot. Gazette, xiii. 153.

† Fertilization of Flowers, 436; and Weit. Beobachtungen, iii. 30.

hymenoptera. The fact that they hold a proportion of over one-third in the list of *Scrophularia* is sufficient evidence that the flower specially favors wasps. I know of no bee-flower on which so many wasps occur as intruders. On the other hand, it is but natural that bees should intrude in a wasp-flower, since it is fairly impossible to construct a wasp-flower from which bees would be entirely excluded.

It certainly is not true that the flowers are not easily discovered by bees, and that the nectar is not attractive to them. Sometimes hive-bees are present in great numbers, and are about the only visitors to be seen.* Sometimes bumble-bee workers are equally abundant, and no wasps will be observed. On the contrary, in the latter part of August and first of September, when the number of flowers is reduced, I have fonnd *Vespa maculata* and *V. germanica* to be the only visitors. This seems to be significant, for, when any flower becomes reduced in numbers, its proper visitors are apt to be the last to leave it.

The *Syrphidæ* and the *Halictus* females visit the flowers mainly for pollen, and, as Prof. Trelease has observed in the case of the latter, they often pay more attention to the flowers in the male stage; but the male *Halictus* and the larger bees visit the flowers for nectar.

On 15 days, between July 12 and September 19, I observed as visitors:

Hymenoptera.—*Apidæ*, (1) Apis mellifica L. ☿, s., ab.; (2) Bombus virginicus Oliv. ☿, s. & c.p., ab.; (3) B. vagans Sm. ♂☿; (4) Melissodes bimaculata Lep. ♂♀: (5); Ceratina dupla Say ♀: (6) Megachile montivaga Cr. ♀; (7) M. infragilis Cr. ♂—all five s. *Andrenidæ*. (8) Agapostemon nigricornis F. ♂, s.; (9) Augochlora pura Say ♂♀, s. & c.p.: (10) Halictus coriaceus Sm. ♂♀, s. & c.p.; (11) H. lerouxii Lep. ♀, s. & c p.; (12) H. fasciatus Nyl. ♂♀, s. & c.p.; (13) H. zephyrus Sm. ♂, s.; (14) H. confusus Sm. ♂♀, s. & c.p. *Vespidæ*, (15) Vespa maculata L.; (16) V. germanica F.: (17) Polistes rubiginosus Lep.; (18) P. metricus Say. *Eumenidæ*, (19) Zethus spinipes Say; (20) Eumenes fraternus Say: (21) Odynerus campestris Sauss.; (22) O. foraminatus Sauss.; (23) O. conformis Sauss.; (24) O. anormis Say; (25) O. pedestris Sauss.: (26) O. pennsylvanicus Sauss. *Philanthidæ*, (27) Philanthus punctatus Say. *Sphecidæ*, (28) Ammophila vulgaris Cr.—all s.

* See Farlow in Amer. Jour. Sci. & Arts, 1871, 3d ser. ii. 51. The plant is, in fact, known in parts of the West as "Simpson's Bee-plant."

Diptera.—*Syrphidæ*, (29) Mesograpta polita Say; (30) M. marginata Say—both f.p.

Lepidoptera.—*Rhopalocera*, (31) Lycæna comyntas Godt. *Pyralidæ*, (32) Scepsis fulvicollis Hübn.

Birds.—*Trochilidæ*, (33) Trochilus colubris L., s. on four days.

Collinsia verna Nutt.*— The plants rise from 3 to 10 inches high and grow in rather large patches, so that the flowers are rendered quite attractive to insects.

The flower resembles a papilionaceous flower in a striking manner. The two-lobed upper lip is white and rises nearly vertically, resembling a vexillum. Below, it is provided with a palate which rests upon the lower lip and forms quite a barrier against unbidden guests, and also requires the visitors to depress the lower lip in order to reach the sweets. The palate is provided with brownish spots which form path-finders. The lower lip is blue. Its lateral lobes represent the wings, and the middle lobe, which is folded longitudinally, corresponds to the keel of a papilionaceous flower.

The four stamens arise on the upper wall of the corolla, but their filaments extend across the tube, their anthers being enclosed in the infolded lobe of the lower lip. The filaments with the hairs upon them completely close the tube. Insects land above the filaments, and can only reach the nectar by inserting their proboscides between them. After a bee has forced its head in under the palate, it still requires a tongue about 3 mm. long to reach to the bottom of the tube. The anthers have their broad faces extending vertically, and, on account of the unequal length of the filaments, are arranged in an irregular row, so that they lie as snugly as possible in the keel-like middle lobe of the lower lip.

After the lip has been depressed, it returns to its position enfolding the anthers. The pollen is thus protected from *Syrphidæ*, *Andrenidæ* and beetles, and can only be collected by bees which are strong enough to depress the lip. The anthers discharge their pollen in succession, those of the longer stamens first. Accordingly, in order to collect all of the pollen, bees must visit each flower several times.

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* See Müller: Fertilization of Flowers, 436.

The stigma stands among the anthers, and sometimes appears receptive before they discharge. When the lower lip is forced down, the stigma may touch the bee in advance of the anthers; but, in the absence of insects, I find nothing to prevent the stigma from receiving pollen from the surrounding stamens. In Müller's "Fertilization of Flowers," 436, it is stated that, in the absence of insects, flowers of this plant and of *C. bicolor* fertilize themselves, and are fertile to their own pollen.

I regard the flower as specially adapted to early-flying bees with abdominal collecting-brushes — i.e. species of *Osmia*— and these bees, although not the exclusive visitors, are far more abundant and more important than all of the other visitors together. As an illustration of the extent to which the economy of these bees is associated with the flower, may be mentioned the fact that the females of the four species found on the flowers all collected pollen, and that they were the only native bees collecting pollen, except a single individual of *Halictus Lerouxii*. *Bombylius*, *Empis*, and butterflies, are mere intruders, since they can reach the nectar without depressing the lower lip, and so without touching anthers or stigma.

In the order to which it belongs, *Collinsia* is remarkable from the fact that it dusts its visitors on the ventral surface instead of on the back. As in the cases of *Verbascum* and *Scrophularia*,* I suppose that the flower originally applied its pollen to the backs of the bees; then that the flower changed so as to expose its stamens in such a way that insects could alight upon them; then the stamens turned to the lower side, and the flower became further modified to suit bees with abdominal collecting-brushes.

In 1890 I found the flowers in bloom from April 21 to June 1. On four days, between April 21 and May 8, I captured the following visitors:

Hymenoptera.—*Apidæ*, (1) Apis mellifica L. ☿, s. & c.p.; (2) Bombus americanorum F. ♀, s.; (3) B. ridingsii Cr. ♀, s.; (4) B. separatus Cr. ♀, s.: (5) B. scutellaris Cr. ♀, s.; (6) B. pennsylvanicus DeG. ♀, s.; (7) Anthophora ursina Cr. ♂, s.; (8) Synhalonia speciosa Cr. ♂, s.; (9) S. honesta Cr. ♂, s.; (10) Ceratina dupla Say ♂♀, s., freq.; (11) Osmia atriventris Cr. ♂♀, s. & c.p., ab.; (12) O. albiventris Cr.

* Bot. Gazette, xiii. 225.

♂♀. s. & c.p.. ab.; (13) O. 4-dentata Cr. ♂♀, s. & c.p.. ab.; (14) O. dubia Cr. ♀, s. & c.p., two; (15) Nomada bisignata Say ♀. s. *Andrenidæ*. (16) Halictus lerouxii Lep. ♀, c.p.

Diptera.—*Empidæ*, (17–18) Empis spp., s. *Bombylidæ*, (19) Bombylius fratellus Wied., s.

Lepidoptera.—*Rhopalocera*, (20) Colias philodice Godt., s.: (21) Nisoniades brizo Bd.-Lec., s.; (22) N. persius Scud., s.

Pentstemon lævigatus Soland., var. *Digitalis* Gray.—The flower is proterandrous, as in *P. campanulatus*.* In the first stage, the style with its undeveloped stigma lies against the upper wall of the corolla. The anthers are dehiscent; rigid teeth on their edges grate against the thorax of the visitor and aid in sifting out the pollen, which is rather dry. Later the style turns down at the tip, opposing the receptive stigma in the entrance.

On the 21st of June, 1888, I saw a common wasp, *Odynerus foraminatus*, Sauss., ♀, going from one flower to another, and, turning to the base of the tube, cut a hole in one side with her sharp jaws and insert her tongue. Then she cut a hole on the other side and again inserted her tongue. The nectar is lodged on each side of the base of the sterile filament, and the wasp showed remarkable intelligence in making a hole on each side. I found a few flowers perforated on one side, but most of the flowers had two holes. Again, in 1889, I found the same wasp perforating the flowers in widely separated localities. I also saw *Odynerus anormis* Say ♀ sucking at the openings, but I did not see it make any. Darwin† states that he found *P. argutus?* with two holes in the upper side of the base of the corolla, but supposes that they were made by bees.

The corolla tube is so broad that large bees can crawl into it. Below, it is narrowed for about 8 mm., so that it takes a long tongue to drain the nectar. The sterile filament renders the nectar less accessible, and bees are required to insert their proboscides on each side of it.

The flower is intended to be visited only for honey by long-tongued bees, and other insects are to be regarded as intruders. Small bees crawl into the narrow part of the tube far enough to

* On the genus, see Müller, "Fertilization of Flowers," 434 & 633.

† "Cross and Self-fertilization of Plants," 436. For other cases of perforation of *Pentstemon*, see Pammel, "On the Perforation of Flowers," Trans. St. Louis Acad. Sci. v. 276.

reach some of the nectar, and they might drain it but for the opposition of the sterile filament. Butterflies also steal the honey, but they, as well as the little bees, are by no means certain to touch the anthers and stigmas.

On 10 days, between May 28 and June 26, I observed the following visitors:

Hymenoptera.—*Apidæ*, (1) Apis mellifica L. ☿; (2) Bombus americanorum F. ♀☿; (3) B. pennsylvanicus DeG. ♀, one; (4) Anthophora abrupta Say ♂♀; (5) Synhalonia atriventris Sm. ♀; (6) S. honesta Cr. ♂; (7) S. speciosa Cr. ♀—all s.; (8) Ceratina dupla Say ♀, c.p.; (9) Megachile montivaga Cr. ♂♀, s.; (10) M. brevis Say ♀, s.; (11) Alcidamea producta Cr. ♂♀. s. & c.p., ♀ reversing to receive pollen in ventral scopa; (12) Osmia albiventris Cr. ♀, s.; (13) O. montana Cr. ♀, s. *Andrenidæ*, (14) Agapostemon nigricornis F. ♀, c.p.; (15) Halictus coriaceus Sm. ♀, c.p.; (16) H. confusus Sm. ♀, c.p.

Lepidoptera.—*Rhopalocera*, (17) Papilio troilus L.; (18) Colias philodice Godt. *Sphingidæ*, (19) Deilephila lineata F.—all s.

Coleoptera.—*Scarabæidæ*, (20) Trichius piger F., f.p.

Mesograpta marginata Say (Syrphidæ) gleans stray pollen, which is scattered npon lower lip.

Pentstemon pubescens Soland.—The flower is male in the first stage, as in the preceding. The corolla tube measures about 15 mm. and is much narrower than in *P. lævigatus*. The narrow part measures about 6 mm. The wide part has two longitudinal folds beneath, which alone almost close the entrance. Then the sterile filament, which is more hairy than in *P. lævigatus*, and the hairs on the lip, also, aid in closing the mouth of the flower. The effect of these modifications is that a longer tongue is required to reach the nectar conveniently.

The flower blooms somewhat earlier than the foregoing and marks the time of appearance of the males of *Anthophora abrupta*, which are the principal visitors, as far as I havé observed. This bee only inserts its head far enough to hide its eyes, and receives the pollen on its hairy face.

On 6 days, between May 12 and June 3, I captured the following insects on the flowers:

Hymenoptera.—*Apidæ*, (1) Bombus vagans Sm. ♀; (2) B. americanorum F. ♀; (3) Anthophora abrupta Say ♂, ab.; (4) Synhalonia speciosa Cr. ♀; (5) S. honesta Cr. ♂; (6) Ceratina dupla Say ♀, crawling into tube; (7) Alcidamea producta Cr. ♂, do.; (8) Osmia atriventris Cr. ♂♀, do.; (9) O. distincta Cr. ♀, do.

Lepidoptera. *Rhopalocera*, (10) Papilio philenor L.; (11) P. asterias F.; (12) Pamphila zabulon Bd.-Lec.

Diptera.—*Bombylidæ*, (13) Bombylius atriceps Lw.—all s.

Gratiola Virginiana L.—The plants grow in thin patches in wet places, and rise about a span high. The flowers are white with the tubes greenish-yellow, the upper wall being densely bearded with yellow hairs. The tubes measure about 8 mm. and are strongly curved upward, so that the bee must turn with its ventral surface toward the anthers in order that its body may fit the tube. Then the dense beard on the upper wall also opposes a bee trying to enter right-side up. But the flower is so nearly erect, and the tube is so strongly curved, that the large upper lip stands almost horizontally, forming a most convenient landing-place. Consequently, it is easier for the bee to enter back downwards than in any other way.

While, therefore, the flower has the appearance of a *nototribe* flower, and no doubt was originally of that kind, the form of the tube has been changed so as to make the flower *sternotribe* by requiring the bee to reverse. Delpino has observed the same thing in *G. officinalis*. The curvature of the tube also has the effect of excluding unbidden guests of long tongues.

I think the flower is specially adapted to small bees of the genus *Halictus*, which are of the right size to enter the tube. In Illinois in June, and in Florida in March, I have found it visited abundantly, both for honey and pollen, by *H. confusus* Sm. ♀. This bee crawls so far into the tube that it is entirely hidden from view.

The anthers and stigma are so closely approximated, that, in the absence of insects, it seems as if self-pollination may readily occur.

Veronica Virginica L.*—The white flowers are crowded in close spikes at the summit of the stalks, and are fertilized by insects crawling over them. They appear to be male at first, the anthers standing 7 mm. beyond the mouth of the tube, and becoming widely separated in the female stage. The corolla tubes measure 5 mm., and the nectar is sought by mid-length and long tongues.

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* On the genus, see Müller, "Fertilization of Flowers," 438 & 634.

I observed the following visitors on 8 days, between July 7 and August 11:

Hymenoptera.—*Apidæ*, (1) Apis mellifica L. ☿, s.; (2) Bombus vagans Sm. ☿, s.; (3) B. americanorum F. ☿, s.; (4) Melissodes bimaculata Lep. ♂. s.; (5) Ceratina dupla Say ♀. s. & c.p.; (6) Alcidamea producta Cr. ♀, s.; (7) Heriades carinatum Cr. ♀, c.p. *Andrenidæ*, (8) Agapostemon nigricornis F. ♂♀, s.;; (9) Augochlora pura Say ♂ ♀. s. & c.p.; (10) Halictus coriaceus Sm. ♀. c.p.; (11) H. confusus Sm. ♀, c.p. *Sphecidæ*, (12) Ammophila procera Klug; (13) Sphex ichneumonea L.

Lepidoptera.—*Rhopalocera*, (14) Pyrameis huntera F.; (15) Chrysophanus thoe Bd.-Lec.; (16) Lycæna comyntas Godt.; (17) Pieris rapæ L. *Pyralidæ*, (18) Scepsis fulvicollis Hübn.; (19) Nemophila noctuella V.; (20) Eurycreon rantalis Guén.—all s.

Diptera.—*Bombylidæ*, (21) Exoprosopa fasciata Macq., s. *Syrphidæ*, (22) Mesograpta geminata Say, f.p.; (23) Eristalis transversus Wied., f.p. *Tachinidæ*, (24) Jurinia apicifera Walk., s.

~~Hymenoptera~~.—*Lygæidæ*, (25) Lygæus turcicus F., s. Hemiptera

Seymeria macrophylla Nutt.—In the American Naturalist, xix. 72, this flower is described and figured by Foerste, and I have little to add to his description, except a list of visitors. The tube of the corolla is strongly compressed horizontally, so that the upper and lower walls are closely applied to each other. In the throat the corolla is strongly bearded, which serves to exclude small intruders, and enables the bees to hold on better when they are collecting pollen.

A bee with a proboscis 9 mm. long can reach the nectar from the outside, while short-tongued bees can reach it by squeezing into the throat. This cannot be accomplished with ease except by the larger and stronger bees.

The style is very short, so that there is nothing to prevent pollen from the anthers being carried back to the stigma.

The plants are scattered under the trees on whose roots they form parasitic attachments. The flowers are yellow, arranged in interrupted, leafy spikes, and are not very conspicuous.

The principal visitors are bumble-bees. On one occasion I counted 67 individuals at work on the flowers. On 6 days, between July 28 and Aug. 8, I observed the following visitors:

Hymenoptera.—*Apidæ*, (1) Apis mellifica L. ☿, s., one; (2) Bombus vagans Sm. ☿. s. & c.p., ab.; (3) B. americanorum F. ☿. s. & c.p.

ab.; (4) B. ridingsii Cr. ☿, s. & c.p., one; (5) B. virginicus Oliv. ☿, s., one; (6) Melissodes bimaculata Lep. ♂, s., one.

Lepidoptera.—*Rhopalocera*, (7) Pieris rapæ L., s.. one; (8) Pamphila zabulon Bd.-Lec.. s., freq.

Diptera.—*Syrphidæ*, (9) Milesia ornata F., f.p., one.

*Gerardia pedicularia** L.—The flowers resemble those of *G. flava*, as shown on plate ii. of Goodale's "Wild Flowers." The upper wall of the corolla tube is straight, while the lower is concave within. The flowers are synacmic. The style, which lies against the upper wall, curves out over the mouth of the corolla. The stigma runs down each side, where it will easily touch a bee entering on either side. The stigma touches the bee far in advance of the anthers, and cannot receive pollen from them. The anther-cells are tipped below with long awns. The pollen is light and dry, and remains in the cells until a bee touches one of the points, when the chink of the anther gapes and a little pollen is sifted out. If the pressure is continued, all the pollen falls out. The pollen is in this way protected from small bees and flies, and is only discharged when a bee is in position to receive it. The hairs on the anthers and filaments are for the bees to cling to when sifting out the pollen.

The most abundant visitor, and the one for which the flower is most perfectly adapted, is *Bombus americanorum*. This bee always turns head-downwards on entering the flower, and inserts its proboscis into the base of the tube for honey. When it enters the flower, or backs out, the basal joints of its legs strike the tips of the anther-cells, when the pollen falls out. I had often wondered why this bee turned up-side down to enter the flower, and at first supposed that it was because she wanted to collect pollen at the same time, and turned so as to dislodge it. But I discovered that the form of the flower requires it; for the male, which is almost as frequent a visitor as the females and workers, and only visits the flower for honey, always reverses, which it certainly would not do unless the form of the flower made it necessary. The modification which requires the bees to reverse is associated with the peculiar mode of pollen-discharge.

* See Bailey, Torr. Bull. ii. 39, and Am. Nat. vii. 689. On *G. flava*, see Bailey, Am. Nat. xiii. 649, and Young, Torr. Bull. iv. 41.

Smaller bumble-bees, and some other bees which never or rarely try to suck, hang under the anthers and work out the pollen by striking the trigger-like awns. They reverse of their own accord, since they are so small they are not compelled to do so on account of the form of the flower. The tube is large and the narrow part only about 10 mm. long, so that most bumble-bee workers could easily reach the nectar if the tube were not curved in the opposite direction from that of most flowers, and if the anthers did not obstruct the entrance. On one occasion, I saw *Bombus separatus* ♂ alight in the mouth of the corolla, and, not knowing how to enter, fly away without obtaining any nectar. Prof. W. W. Bailey mentions that small bumble-bees, which he saw sucking at holes in the flower, were baffled when they attempted to go in at the mouth. If these bees made the holes at which they were sucking, it was no doubt because they did not know how to reach the nectar in the proper way.

Although the flower secretes nectar and is enabled to increase its set of visitors in this way, the chief attraction is the pollen. Early in the morning the bees are busy collecting the pollen, but as soon as it is gone they are less attentive, aud the flower soon withers.

The following visitors were observed on eight days, between Aug. 21 and Sept. 14:

Hymenoptera.—*Apidæ*, (1) Bombus virginicus Oliv., ☿, s. & c.p.; (2) B. separatus Cr. ☿, c.p.; (3) B. vagans Sm. ☿, s., once; (4) B. americanorum F. ♂ ♀ ☿, s. & c.p., ab; (5) Megachile mendica Cr. ♀, c.p.

Birds.—*Trochilidæ*, (6) Trochilus colubris L., once; front and base of bill white with pollen. It is interesting to note that, while the bees must alight and reverse to get the nectar, the humming-bird can obtain it while on the wing. *Halictus confusus* Sm. ♀ visits the flower for stray pollen.

Gerardia purpurea L.—The form of this flower resembles that of the preceding, but the flower is much smaller and of a handsome purple color. The upper wall of the corolla is straight, while the lower is curved and longer, so that, when the flower stands horizontally, the mouth looks upward and forward. As in *G. pedicularia*, this form of the corolla requires the bees to reverse to reach the nectar. On one occasion I saw a worker of

Bombus americanorum visiting flowers of this plant and of *G. auriculata* indiscriminately. On *G. auriculata* it entered in an upright position, but always turned up-side down to reach the nectar of *G. purpurea*. The style with its lateral stigmatic surfaces projects across the upper part of the mouth of the corolla, and bees enter on each side of it. The anther-cells are not awned as in *G. pedicularia*, but merely pointed, and the pollen is sifted out in a similar manner. Some smaller bees which do not attempt to reach the nectar, and are not required to reverse, do so in order to dislodge the pollen.

The flower is visited mainly for pollen. The fall of the flower has little reference to the secretion of nectar; I have seen *B. americanorum* visiting the flowers for nectar, and falling to the ground with nearly every flower it entered. The narrow part of the tube is about 5 mm. long.

On 6 days, between Sept. 6 and 26, I observed as visitors:

Apidæ, (1) Bombus americanorum F. ♂♀☿, s. & c.p., ab.; (2) B. virginicus Oliv. ☿. s. & c.p., one; (3) Melissodes perplexa Cr. ♀, c.p.; (4) Megachile brevis Say ♀, s. & c.p.

Lepidoptera.—*Rhopalocera*, (5) Pamphila sp., s., one.

Gerardia tenuifolia Vahl.—A good illustration of this flower is on plate ii. of Goodale's "Wild Flowers." It is short and broad, with purple lobes. The tube within is white and spotted with purple. The narrow part of the tube is so short that a proboscis 2 or 3 mm. long can reach to the bottom of it. In a general way the flower agrees with that of *G. purpurea*, but the tube is so short that bees are not compelled to reverse. Accordingly, when sucking they take an upright position, but when collecting pollen they hang to the hairy stamens and work out the loose pollen with their legs. The pollen is the chief source of attraction, and the flower, on account of its abundance, occupies an important place in the economy of bumble-bees as a pollen-flower. On account of the short tube, the flowers are sought by a greater number of species and more individuals of each than in the two preceding.

On ten days, between Aug. 26 and Sept. 12, I observed the following visitors:

Hymenoptera.—*Apidæ*, (1) Apis mellifica L. ☿, s. & c. p., ab.; (2) Bombus virginicus Oliv. ☿, s. & c.p., ab.; (3) B. separatus Cr. ☿, c.p.;

(4) B. americanorum F. ♀ ☿, s. & c.p., ab.; (5) B. scutellaris Cr. ☿, c.p.: (6) Melissodes perplexa Cr. ♀, c.p.; (7) Ceratina dupla Say ♀, s.: (8) Megachile brevis Say ♀, c.p.; (9) M. mendica Cr. ♀, c.p.; (10) Calliopsis andreniformis Sm. ♂ ♀, s. & c.p.

Lepidoptera.—*Rhopalocera*, (11) Pieris rapæ L.; (12) Colias philodice Godt.; (13) Pamphila sp.—all sucking, but mere intruders.

Halictus confusus Sm. ♀ collects stray pollen. *Syrphus americanus* Wied. and other *Syrphidæ* eat stray grains. *Pyrota mylabrina* Chev. (Meloidæ) gnaws the petals and anthers.

Gerardia auriculata Michx. — Resembles *G. tenuifolia*, but the corolla is somewhat larger and longer, and the style is not so far advanced in front of the anthers. The narrow part of the tube is about 4 mm.; but nectar seems to be of little importance, since the flower is visited almost exclusively for pollen. Like most pollen-flowers, it is visited early in the morning, and soon withers.

On Aug. 30 and Sept. 1st I observed as visitors —

Apidæ, (1) Bombus americanorum F. ☿, sucks in an upright position, but reverses to collect pollen; (2) B. pennsylvanicus DeG. ☿, s. one; (3) B. virginicus Oliv. ☿, s. & c.p.; (4) Melissodes perplexa Cr. ♀, c.p., reversing; (5) Megachile brevis Say ♀, s. & c.p., reversing.

Halictus confusus Sm. ♀ collects pollen which falls on the lower lip.

Under the head of "Tipo violaceo" Delpino* includes flowers which are so formed that their guests must turn up-side down in order to reach the sweets. As examples he mentions *Viola*, *Gratiola officinalis*, and *Epipogum Gmelini*. To this number must be added *Gratiola Virginiana*, *Gerardia pedicularia*, and probably its allies of the section *Dasystoma*, and *G. purpurea*. *Viola* (and probably *Epipogum Gmelini*) has no doubt become fitted to its visitors and then changed to an inverted position, so that the insects must invert also. These inverted flowers, therefore, retain their original relations to their pollinators; *Viola* still dusts them on the underside, and *Epipogum* fastens its pollinia on their uppersides. But the *Gratiolas* and the *Gerardias* originally applied their pollen to the insect's back, so that the form which compels the insect to reverse changes the flower from *nototribe* to *sternotribe*. The *Gerardias* have de-

* Ulteriori osservazioni.

veloped the habit of holding up their pollen until the points on the anthers have been touched by a bee. The bee, on the other hand, has acquired the habit of turning and hanging to the stamens in order to dislodge the pollen with its legs, and this habit is an advantage to the bee and to the flower also. *G. pedicularia* and *G. purpurea* have, therefore, acquired a form which requires even male bees, which do not come for pollen, to turn and enter the flowers so that they will be certain to strike the anther-points with their legs. Flowers of the "Tipo violac~~i~~o" are apt to e
have some intruders which suck without turning, such as *Bombylius* on *Viola*, and the humming-bird on *G. pedicularia*.

Castilleia coccinea Spreng. — The flowers are subtended by broad, 3-cleft leaves. or bracts, which are bright scarlet at the summit, and form the most attractive part of the inflorescence. The calyx is laterally compressed, cleft in front and behind, and is scarlet at the tip. The pale corolla is also compressed and is included in the calyx. The lower lip is almost entirely aborted, being reduced to three small points. There is, therefore, nothing about the flower which can be considered as a landing-place for insects. The anthers are inclosed in the upper lip, which is long and narrow. The mouth of the corolla is closed. When a pencil-point is thrust into the throat, the upper lip opens and is thrown forward, so that the anthers are brought against the pencil. The style is exserted, holding the stigma over the mouth of the flower, and this also is thrown forward when anything separates the lateral edges of the mouth. The stigma strikes the visitor in advance of the anthers, and this secures cross-fertilization.

The scarlet color and the absence of a landing-place suggest that the flower is adapted to humming-birds, and the ruby-throat (*Trochilus colubris* L.) is the only visitor I have observed, although bumble-bees and butterflies may sometimes occur, since the tube is only about 15 mm. deep. The plant blooms about the time of arrival of *Trochilus* from the south. In 1886 the first humming-bird seen was on May 5, visiting the *Castilleia*.

Carlinville, Ill.

FLOWERS AND INSECTS:

UMBELLIFERÆ.

BY CHARLES ROBERTSON.

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Flowers and Insects — UMBELLIFERÆ.*

BY CHARLES ROBERTSON.

The Umbelliferæ have remarkably uniform flowers, the nectar being generally exposed, or at most only slightly concealed by the incurved petals; and, since they bloom in succession from early spring to late autumn, are particularly well suited for an investigation which aims to discover the effect of the time of blooming on the character of the visitors. It is obvious that a flower must depend for visitors not only upon the fauna of the region in which it grows, but upon the insects which are flying while it blooms.† Accordingly, I have arranged the plants in the order of blooming, or at least in the order in which they were observed. This will enable us to consider the order in which they succeed one another, their relations to the particular insect fauna upon which they depend, and to the general insect fauna which reaches its maximum of variety in the hot summer. We can compare a plant with one blooming earlier or later, can discover peculiarities in the lists which are due to time of blooming, and can eliminate this cause to ascertain the effect of difference of structure.

For aid in the determination of the bees I am indebted to Mr. E. T. Cresson, of the flies to Dr. S. W. Williston, of the beetles and bugs to Mr. C. A. Hart. The Chalcids, as far as made out, were named for me by Mr. L. O. Howard. My collecting and identification of the minute hymenoptera and diptera are very imperfect. The flowers with exposed nectar are very abundantly visited by these forms, but to collect them requires special attention to them. Then, they have been so imperfectly studied, that it is hard to determine them or to assort them accurately.

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* Compare especially Müller: Fertilization of Flowers, Weitere Beobachtungen, and Alpenblumen. Also Schulz: Beiträge zur Kentniss der Bestaübungseinrichtungen und der Geschlechtsvertheilung bei den Pflanzen.

† The importance of the time of blooming is especially emphasized by MacLeod: Statistiche Beschouwingen omtrent de Bevruchting der Bloemen door de Insecten, Botanisch Jaarboek, eerste jargang, 1889, Gent.

I withhold for the present the lists of visitors in order to complete the determination of certain groups, and to raise the number in certain lists, so that the comparisons can be more satisfactorily made. The tables give the number of species of the several groups. Unless otherwise stated, the observations were made near Carlinville, Ills.

Erigenia bulbosa, Nutt.—On the first warm days of spring this plant raises its small white umbels just above the leaves. The plants often form rather large patches, so that they are very attractive to insects, furnishing both honey and pollen in great abundance. All of the flowers are hermaphrodite, and, from a careful examination, I am satisfied that Foerste* is correct in regarding them as proterogynous.

The petals are longer than in most umbellifers and are not so widely expanded, so that the disc is not so freely exposed as in many of the following species. In the female stage especially, the petals are more erect, and the incurved stamens aid in concealing the nectar.

A flower blooming so early as Erigenia does, cannot be sure to find a set of flower-loving insects waiting for it, for anthophilous insects cannot afford to appear until they are sure of a floral diet. But any weather warm enough to bring out Erigenia flowers is certain to bring out a set of insects which are able to do good work until the flower-insects come. The first day I found Erigenia in bloom in 1889 was on March 21st, when I noted as visitors Apis mellifica, Gonia frontosa, Lucilia cornicina, Scatophaga squalida, and a Sarcophagid. With the exception perhaps of Gonia, all of these insects may be observed on any warm day during the winter. The hive-bee is introduced and so must always be regarded as an intruder on native flowers. None of the other insects depend upon a floral diet. We see, therefore, that Erigenia is sure of the visits of flesh-flies and dung-flies at any time it may appear. It would be effectually cross-fertilized if it depended upon Lucilia cornicina alone. The plant has an advantage over Dicentra Cucullaria,† which has to wait for long-tongued bees. On March 23d I found among the visitors Andrena hirticeps ♂ and Brachypalpus frontosus—the first of the native flower-insects. On the 26th I found 7 Andrenidæ and 2 Syrphidæ, so that this was the first day when the set of visitors showed an anthophilous character.

As a result of early blooming, however, Erigenia is so far from suffering in the character of its visitors that it is the highest specialized of the family, for it shows the largest proportion of bees. Of 62 species of insects captured on the flowers, 28 are hymenoptera, and all of these are bees except a single Chrysid. During the time when this plant is in bloom I have observed no other hymenoptera flying except Tenthredinidæ and Parasitica; these appear to be rare. The preponderance of bees, therefore,

* Bot. Gazette, vii., 70.

† Bot. Gazette, xiv., 125.

is not a result of structural adaptation to them, but of the paucity of the early fauna in lower hymenoptera. By referring to the table it will be seen that only two other species show as many bees, viz., Zizia and Pastinaca. In the first place, these are exposed to a more numerous bee-fauna. But while Erigenia shows 27 bees in competition with 1 hymenopteron and 34 other species, Zizia shows 35 bees in competition with 32 hymenoptera and 64 other species, and Pastinaca 30 bees against 97 hymenoptera and 148 other insects. In Erigenia bees are nearly ½, in Zizia nearly ⅓, in Pastinaca less than ⅑ of the number of visitors.

Erigenia agrees with all of the earlier species, except those with concealed nectar, in showing a preponderance of flies over hymenoptera, and this is also a result of the absence of competition of the lower hymenoptera. The list of visitors is peculiarly rich in bees of the genus Andrena, another result of early blooming.

Chærophyllum procumbens, Crantz.—The plant grows in rather thin patches in dark woods. The umbels contain three or four small flowers, which bloom in succession and are very inconspicuous. The flowers are hermaphrodite, imperfectly proterandrous or homogamous, with short stamens and styles. Sometimes I have found a dehiscent anther in contact with the stigma, but even then most of the stigmatic surface remains bare and ready to receive pollen from other flowers. However, all of the flowers appear fruitful even in bad weather, so I think self-fertilization always occurs in the absence of insects.

The plant blooms next after Erigenia. The inconspicuousness of the flowers is compensated for by a rich supply of nectar, so that I was enabled to take 50 species of insects in three days. The nectar is more freely exposed, and, as a consequence, we find fewer bees than in Erigenia and an increased proportion of other insects. This is first to show Parasitica.

Zizia aurea, Koch.—The plants grow in rather large patches, which are made conspicuous by the yellow umbels. Five umbels of each order produced an average of flowers and umbellets as follows:

1st order—294	male and	37	hermaphrodite	flowers in	15 umbellets.
2d order—170	"	" 178	"	"	" 18 "
3d order— 89	"	" 101	"	"	" 14 "

The primary umbel commonly bears only male flowers: the proportion of hermaphrodite flowers increases in umbels of 2d and 3d orders. The fruitful umbellets have male flowers within, except a single central flower which is hermaphrodite. The hermaphrodite flowers are proterogynous. While the primary umbel is discharging pollen, the hermaphrodite flowers of the secondary umbels protrude their receptive stigmas. Then they and the male flowers discharge pollen to supply the first stage of flowers of the umbels of the 3d order.

The nectar is concealed by the inflected petals, and in the first stage by the incurved stamens. This plant is first to show Scoliidæ, Pompilidæ, Crabronidæ, and Eumenidæ, which are now flying. The number

of bees is larger than in any other species in the table. Compared with Erigenia, this is owing to concealment of nectar and to the presence of a more numerous bee-fauna. Compared with Eryngium, which has more deeply-seated honey, it is owing to a smaller number of competitors, resulting from early blooming. The proportion of bees to other hymenoptera is reduced by the appearance of lower forms. The proportion of diptera is reduced by concealment of nectar.

Polytænia Nuttallii. DC.—This plant agrees with Zizia aurea in color, proterogyny, time of blooming, mode of nectar concealment, and in the general character of its visitors. Five umbels of each order produced an average of flowers and umbellets as follows:

1st order—335	male	and	9	hermaphrodite	flowers	in 14	umbellets.
2d order—275	"	"	120	"	"	" 18	"
3d order— 48	"	"	55	"	"	" 11	"

The primary umbel is, as a rule, entirely male, the proportion of hermaphrodite flowers increasing in the secondary and tertiary umbels. On a plant bearing umbels of the 4th order, the primary and all of the secondary umbels bore only male flowers; an umbel of the 3d order bore 384 male and 74 hermaphrodite flowers in 18 umbellets; one of the 4th order bore 63 male and 54 hermaphrodite flowers in 12 umbellets.

Osmorrhiza longistylis. DC. — Five umbels of each order bore an average of flowers and umbellets as follows;

1st order—58	male	and	27	hermaphrodite	flowers	in 6	umbellets.
2d order—47	"	"	18	"	"	" 6	"
3d order—38	"	"	15	"	"	" 5	"
4th order—29	"	"	11	"	"	" 5	"

The hermaphrodite flowers are proterandrous, and the proportion of male flowers remains about the same in umbels of all orders. The flowers are white. The nectar is fully exposed, and, as a consequence, the number of diptera equals the number of hymenoptera.

Sanicula Marilandica. L.—The umbels contain 1 to 4 hermaphrodite flowers surrounded by from 20 to 70 male flowers. The styles of the hermaphrodite flowers are strongly exserted from the start, and, although without receptive stigmas at first, the stigmas develop before dehiscence, so that the flower is proterogynous. When the stamens become dehiscent, the styles are strongly recurved, holding the stigmas down against the sides of the ovary. Sometimes the petals hold an anther so firmly between them that it is not released until it has lost its pollen.

S. europæa has the styles exserted at first, but Schulz* regards it as proterandrous.

The petals are incurved so that they cover the disc, making the nectar less accessible to the shortest tongue. Accordingly, the list shows more hymenoptera than diptera. Although the heads are by no means showy, a rich supply of nectar insures an abundance of industrious visitors.

* l. c.

Heracleum lanatum, Mx.—This plant bears large umbels of white flowers. Well developed plants have 2 or 3 secondary umbels and sometimes one of the third order. Five umbels of each order bore an average of flowers and umbellets as follows:

1st order—	0	male and	420	hermaphrodite flowers	in	19	umbellets.
2d order—	120	" "	303	"	"	" 20	"
3d order—	389	" "	46	"	"	" 20	"

As a rule, the primary umbel is entirely hermaphrodite, and umbels of the third order are entirely male. A single umbel (primary), borne on a weak plant, produced 160 male and 94 hermaphrodite flowers in 14 umbellets. The opposite of what occurs in Zizia and Polytænia, the proportion of hermaphrodite flowers decreases from the primary umbel. The hermaphrodite flowers are proterandrous.

This is the first plant to show Larridæ and Sphecidæ. On account of the exposed situation of the nectar, we find a diminution in the proportion of bees and an increase in Parasitica, Crabronidæ, and especially of diptera. I found more flies on Heracleum than on any other umbellifer except Pastinaca. But Pastinaca shows only 7 more flies in a much larger list. Heracleum is especially rich in Syrphidæ, showing 21 species in a list of 174 visitors, while Pastinaca shows only 22 species in a list of 275. The list is also rich in Crabronidæ, especially species of Crabro. Cicuta shows an equal number, Crabro being partly replaced by Oxybelus.

Pimpinella integerrima, Benth. & Hook.—This agrees in a general way with Zizia and Polytænia, and should be compared with them. Five umbels of each order produced an average of flowers and umbellets as follows:

1st order—	409	male and	0	hermaphrodite flowers	in	14	umbellets.
2d order—	174	" "	72	"	"	" 14	"
3d order—	35	" "	47	"	"	" 9	"

A primary umbel on a plant bearing only 1 umbel produced 36 hermaphrodite flowers, with many male ones, in 17 umbellets. The hermaphrodite flowers are proterogynous.

Eulophus Americanus, Nutt.—The flowers are white. Five umbels of each order produced an average of flowers and umbellets as follows:

1st order—	25	male and	182	hermaphrodite flowers	in	13	umbellets.
2d order—	159	" "	13	"	"	" 12	"
3d order—	51	" "	0	"	"	" 7	"

Commonly, umbels of 1st order contain only hermaphrodite flowers, those of the 2d order only male flowers. Umbels of the 3d order are rare and entirely male. The hermaphrodite flowers are proterandrous.

From their early blooming and fully exposed nectar, Eulophus and Heracleum show the greatest proportion of flies. Eulophus shows 52 flies in a list of 97. Tiedmannia, which is exposed to a richer hymenopterous fauna, shows 52 flies in a list of 156.

Thaspium aureum, Nutt.; var. *trifoliatum*, C. & R.—Resembles Zizia, Polytænia, and Pimpinella. Five umbels of each order bore an average of flowers and umbellets as follows:

1st order—174 male and	37 hermaphrodite flowers	in	11 umbellets.
2d order— 98 " "	90 "	" "	10 "
3d order— 57 " "	98 "	" "	12 "

var. *atropurpureum*, C. & R.

1st order—170 male and	13 hermaphrodite flowers	in	11 umbellets.
2d order—129 " "	80 "	" "	12 "
3d order— 94 " "	85 "	" "	11 "

Umbels of the 1st order are commonly male. The hermaphrodite flowers are proterogynous.*

Pastinaca sativa, L. ("adv. from Eur.")—Schulz† has observed that the primary umbels contain principally hermaphrodite flowers, while the number of male flowers increases in umbels of the 3d order. The hermaphrodite flowers are proterandrous, as is well known.

The large umbels of yellow flowers are very attractive to insects. The nectar is freely exposed. In comparing the lists it must be remembered that this is the largest one, much more time having been given to it than to any other plant. It shows the first Nyssonidæ, and an increase in all hymenoptera except Crabronidæ, Andrenidæ, and Apidæ. Although observed nearly four times as much as Heracleum, it shows only 5 more flies. Heracleum shows 20 more flies than hymenoptera, while Pastinaca shows 35 more hymenoptera than flies.

In the Fertilization of Flowers, 284, and Weitere Beobachtungen, i., 36, Müller gives a list of 7 diptera and 8 hymenoptera. In the former he says: "So the dull yellow flowers of this plant, like those of Buplurum and Anethum, are visited by Diptera and Hymenoptera, not by Beetles." Again, on p. 287, he says: "As a peculiarity which influences this assemblage of insects. I must mention the yellow color, for I have never found the flowers of Buplurum, Silaus, or Pastinaca, visited by beetles." This generalization was founded in the case of Buplurum falcatum on a list of only 8 visitors, and he afterwards, in the Weit. Beobachtungen, records the occurrence of beetles on B. falcatum as well as on B. rotundifolium. In a list of 46 species found in Anethum, no beetle occurs, but this may be accidental. The list of visitors of Silaus is very fragmentary, containing only 3 insects. In Bot. Gazette vii., 24, Foerste mentions beetles as visitors of Pastinaca, and on page 27 of the same Prof. Trelease refers to Müller's statement. Finally, I have found Pastinaca to be visited by 40 species of beetles, which is nearly twice as many as Müller ever found on any plant of the order.

* Foerste seems to have regarded some species of Thaspium(?) as proterogynous. See Bot. Gazette, vii, 71.

† l. c.

Cicuta maculata, L.—Five umbels of each order bore an average of flowers and umbellets as follows:

1st order—	4 male and	485	hermaphrodite flowers	in	16	umbellets.
2d order—	127 " "	824	"	" "	28	"
3d order—	360 " "	448	"	" "	27	"
4th order—	438 " "	43	"	" "	22	"

As a rule, umbels of 1st order bear only hermaphrodite flowers, those of 4th order only male flowers. The hermaphrodite flowers are proterandrous.

This plant bears many large umbels of white flowers with fully exposed nectar. Cicuta was observed nearly three times as much as Heracleum, but Heracleum shows 15 more flies. As we have observed, Heracleum has 20 more flies than hymenoptera, but Cicuta has 71 more hymenoptera than flies, nearly twice as many. While diptera reach their maximum on Heracleum, hymenoptera reach their maximum on Cicuta. It is the first to show Bembecidæ. Compared with Pastinaca, which blooms earlier, it shows an increase in all hymenoptera except Parasitica, Philanthidæ, Eumenidæ, Andrenidæ, and Apidæ. The Parasitica would no doubt equal the numbers taken on Pastinica, or Sium, if I had given the same attention to the collection of them, and then the extent of the preponderance of hymenoptera on Cicuta would have been better indicated.

Eryngium yuccæfolium, Mx.—Agrees in general with E. campestre, as described and figured by Müller in the "Fertilization of Flowers," 271. Although the styles are strongly exserted from the first, they do not seem to become receptive until after the pollen is discharged, so that the flower is proterandrous. The early elongation of the styles seems to be to obstruct the passage to the nectar, so as more effectually to exclude short-tongued insects. The nectar is more deeply seated than in any other species here considered, and, as a consequence, we find a marked increase in insects of large size and long tongues. Compared with Zizia, we find a smaller number and proportion of bees, on account of the increased abundance of other hymenoptera. We also find fewer diptera, on account of deeper honey and competition of hymenoptera.

But the effect of deep-seated honey is best shown by comparison with Cicuta, which was observed nearly equally and under equally favorable conditions, and, since they bloom at the same time, they are exposed to the same kinds of insects, so that the differences in the lists may be referred to differences in floral structure. The Parasitica are limited to Leucospis. Chrysididæ and Nyssonidæ are absent. Pompilidæ fall from 20 to 6; Larridæ from 12 to 3; Crabronidæ from 14 to 4; Sphecidæ from 12 to 8. The larger and longer-tongued species—Scoliidæ, Philanthidæ, and Eumenidæ—remain about the same, while the large Bembecidæ show an increase. There is marked increase in long-tongues, such as Apidæ, Bombylidæ, Conopidæ, and lepidoptera. Indeed, the list shows more Bom-

bylidæ, Conopidæ, and lepidoptera, than on any other umbellifer, and more Apidæ than any other except Zizia.

E. campestre, according to Schulz,* has the first umbels with only hermaphrodite flowers, and the last with only male ones. Müller's list of 24 species wholly fails to indicate the character of visitors favored by the floral structure.

Sium cicutæfolium, Gmelin.—Five umbels of each order bore an average of flowers and umbellets as follows:

1st order—	0	male and	415	hermaphrodite flowers	in	13	umbellets.
2d order	0	" "	689	"	" "	22	"
3d order—	0	" "	521	"	" "	21	"
4th order—	279	" "	58	"	" "	16	"

Umbels of the 4th order are usually entirely male. In less vigorous plants, umbels of the 4th order are wanting, and those of the 3d are entirely of male flowers. The hermaphrodite flowers are proterandrous.

This plant closely resembles Cicuta, but the list is much smaller, since they do not grow under conditions as favorable for observation.

The list shows more species of Bombylidæ than in Eryngium, but the five species were represented by only one individual of each.

Tiedmannia rigida. C. & R.—Five umbels of each order bore an average of flowers and umbellets as follows:

1st order—	27	male and	594	hermaphrodite flowers	in	23	umbellets.
2d order—	385	" "	70	"	" "	19	"

In well developed plants the primary umbels are entirely of hermaphrodite flowers, and umbels of the 2d order are entirely male. Umbels of the 3d order are rare and contain only male flowers. They represent umbellets of secondary umbels. Twenty plants bore 20 umbels of 1st order, 50 of the 2d, and 2 of the 3d. The hermaphrodite flowers are proterandrous.

In regard to visitors, Tiedmannia agrees essentially with Cicuta and Sium, but there seems to be a tendency for hymenoptera to fall off, probably on account of the late blooming. Thus Sium shows 25 more hymenoptera, but only 6 more flies. Cicuta shows 63 more hymenoptera and only 20 more diptera.

Hydrocotyle umbellata, L.—I found only hermaphrodite flowers, which are proterandrous. While the anthers are discharging pollen the styles are bent over upon each other.

The plant was observed at Orlando, Florida, in March, and, although it blooms earlier than Erigenia in Illinois, it shows insects which do not occur when Erigenia is in bloom. It agrees with early species having fully exposed nectar in showing a preponderance of diptera.

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* l. c.

Review of the Umbelliferæ.

In a general way, insects increase in numbers as it becomes warmer, and we may expect to find more species on the later forms.

Flies are common throughout. They show a preponderance in the lists of early species, except those with concealed nectar. They reach their maximum proportion on Heracleum and Eulophus. In Cicuta they decrease on account of increased competition with hymenoptera, and in Eryngium also on account of concealment of nectar. As far as the food of the adults is concerned, the earlier months seem to be much more favorable to flower-flies.

Bees also appear to be equally common throughout, only Zizia and Pastinaca showing more species than Erigenia. The flowers with concealed nectar and those blooming in early spring are most favorable to them.

Other families of hymenoptera show a marked increase in number of species from early spring. A few forms appear as the season advances, and they reach their maximum in July and August. The Eumenidæ and Crabronidæ are the only families in which the increase is not well marked. We can best understand the changes in the lists if we regard the bees and flies as practically stationary, their proportions and their actual numbers in the lists being reduced by the increase in numbers and the competition of the lower hymenoptera.*

The character of the visitors of Umbelliferæ, therefore, must depend upon the insects to which they are exposed, i.e., upon the time of blooming. Indeed, the time of blooming is almost or quite as important as modifications to hide the nectar. If we take three white-flowered forms with exposed nectar, but appearing at different times, we will find the extremes in character of visitors. Thus, Erigenia shows the highest proportion of bees, Eulophus the highest proportion of flies and Cicuta the highest proportion of lower hymenoptera. Zizia, Polytænia and Eryngium agree in showing a preponderance of hymenoptera over flies as an effect of concealment of honey. Pastinaca, Cicuta and Sium show the same result as an effect of time of blooming. Forms with hidden nectar also show marked contrasts on account of time of blooming. Thus, in the case of Zizia, which blooms in May, one-half of the hymenoptera are bees, while in Eryngium, which has more deeply-seated honey but blooms in July, only one-third of the hymenoptera are bees.

Concealment of nectar, however, accomplishes one important result which cannot be accomplished by change of time of blooming, and that is the simultaneous exclusion of flies and short-tongued hymenoptera. The effect of concealment of nectar can only be ascertained by comparison with a form having free honey, and blooming at the same time as Eryngium with Cicuta.

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* See Table II.

In Erigenia bulbosa. Chærophyllum procumbens and Hydrocotyle umbellata I found only hermaphrodite flowers; all of the other species bear male flowers as well. Male flowers are most abundant in the centre of the umbels, in the centre of the umbellets, and on the side of the umbellets which is nearest the centre of the umbel. It follows that hermaphrodite flowers are most abundant on the outside of the umbels, on the outside of the umbellets, and on the side of the umbellets which is nearest the outside of the umbel. In Sanicula, however, the hermaphrodite flowers are central. and in Zizia the fruitful umbellets commonly have a single, central hermaphrodite flower.

Erigenia, Zizia. Thaspium, Polytænia, Pimpinella, and Sanicula Marilandica, have the styles strongly exserted, and are abundantly visited by insects before the anthers are dehiscent. From a careful examination of the styles in all stages, I am satisfied that they are proterogynous. With the exception of Erigenia, they have the nectar concealed by the incurved petals. In the character of their insect visitors, with the exception of Eryngium, they are the most highly specialized of Umbelliferæ.

In the proterogynous species—Zizia, Thaspium, Polytænia, and Pimpinella—the primary umbel commonly contains only male flowers to supply the first stage of the secondary umbels, and the proportion of hermaphrodite flowers increases in umbels of the 2d and 3d orders. On the other hand, the proterandrous species—Heracleum, Eulophus, Pastinaca, Cicuta, Sium, and Tiedmannia—commonly have the primary umbels entirely of hermaphrodite flowers, and the last umbels entirely male, to supply the pollen for the second stage of the preceding umbels. This difference in behavior goes to support the view that the plants mentioned in the former group are really proterogynous.

In well developed plants the first and last umbels thus tend to specialization; but when the flowers are reduced to a single primary umbel, as in the plants mentioned under Heracleum and Pimpinella, this umbel contains both male and hermaphrodite flowers.

Umbelliferæ.—Table I.

		No. Days.	Dates.	Tenthredinidæ & Parasitica.	Chrysididæ.	Formicidæ & Mutillidæ.	Scoliidæ.	Pompilidæ.	Sphecidæ.	Larridæ.	Bembecidæ.	Nyssonidæ.	Philanthidæ.	Crabronidæ.	Eumenidæ.	Vespidæ.	Andrenidæ.	Apidæ.	Bombylidæ & Conopidæ.	Syrphidæ.	Muscidæ.	Other Diptera.	Coleoptera.	Hemiptera.	Lepidoptera.	Neuroptera.	Total.
1	Erigenia bulbosa	15	Mar. 20–Apr. 21	...	1	...	...	...	...	...	...	...	...	...	...	...	21	6	1	10	17	2	2	...	2	...	62
2	Chærophyllum procumbens	3	Apr. 27–29	8	...	...	...	...	...	...	...	...	...	...	...	...	9	3	...	10	13	2	4	1	...	...	50
3	Zizia aurea	6	May 7–26	9	1	...	1	3	...	...	...	...	...	9	9	...	23	12	1	3	36	8	11	2	3	...	131
4	Polytænia Nuttallii	4	May 9–26	2	...	...	1	...	...	...	...	...	...	3	8	1	9	2	...	1	10	2	1	1	...	...	41
5	Osmorrhiza longistylis	5	May 11–23	...	...	...	...	...	...	...	...	...	...	...	2	...	7	1	...	6	2	2	1	1	...	...	22
6	Sanicula Marilandica	3	May 14–23	1	...	...	...	...	...	...	...	...	...	...	2	...	10	1	...	2	7	4	...	2	...	...	29
7	Heracleum lanatum	7	May 25–Jun. 14	18	1	...	1	3	3	1	...	...	...	13	8	1	13	5	5	21	50	11	13	2	5	...	174
8	Pimpinella integerrima	2	May 29–Jun. 2	...	...	...	...	...	...	...	...	...	...	1	...	...	6	3	1	6	...	2	3	...	1	...	23
9	Eulophus Americanus	2	June 8–11	9	2	1	...	3	2	...	...	...	1	7	3	1	7	...	1	12	32	7	7	2	...	...	97
10	Cryptotænia Canadensis	2	June 15–July 9	5	...	1	...	1	...	...	...	...	1	3	3	...	11	1	1	8	9	4	10	1	...	...	59
11	Pastinaca sativa	26	June 2–July 9	39	3	2	2	10	7	2	...	1	5	12	12	2	22	8	3	22	56	10	40	6	9	1	275
12	Cicuta maculata	19	July 8 to Aug 13	21	6	4	7	20	12	12	3	3	5	14	8	7	15	6	4	14	45	9	14	1	8	...	238
13	Eryngium yuccæfolium	10	July 14–Aug. 8	1	...	1	6	6	8	3	6	...	6	4	9	1	14	11	10	11	18	2	8	2	20	...	147
14	Sium cicutæfolium	20	July 20–Aug. 27	37	3	1	4	8	7	4	1	2	6	10	6	3	9	4	5	11	37	5	19	4	5	...	191
15	Tiedmannia rigida	7	Aug. 14–Sept. 8	28	4	3	4	6	5	5	1	1	2	7	4	2	7	1	2	6	41	3	16	4	3	1	156
16	Hydrocotyle umbellata (Fla.)	3	Mar. 15–20	...	...	...	1	5	...	2	...	...	...	1	...	...	...	1	...	4	18	...	3	...	...	...	35

Umbelliferæ. – Table II.

	Hymenoptera.	Diptera.	Other Insects.	Bees.	Other Hymenoptera.	Diptera.
WITH EXPOSED NECTAR:						
Erigenia bulbosa	28	30	4	27	1	30
Chærophyllum procumbens	20	25	5	12	8	25
Osmorrhiza longistylis	10	10	2	8	2	10
Heracleum lanatum	67	87	20	18	49	87
Eulophus Americanus	36	52	9	7	29	52
Cryptotænia Canadensis	26	22	11	12	14	22
Pastinaca sativa	127	92	56	30	97	92
Cicuta maculata	143	72	23	21	122	72
Sium cicutæfolium	105	58	28	13	92	58
Tiedmannia rigida	80	52	24	8	72	52
WITH CONCEALED NECTAR:						
Zizia aurea	67	48	16	35	32	48
Polytænia Nuttallii	26	13	2	11	15	13
Sanicula Marilandica	14	13	2	11	3	13
Pimpinella integerrima	10	9	4	9	1	9
Eryngium yuccæfolium	76	41	30	25	51	41

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FLOWERS AND INSECTS — LABIATÆ.

CHARLES ROBERTSON.

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FLOWERS AND INSECTS—LABIATÆ.

CHARLES ROBERTSON.

Teucrium Canadense L.—The plant is rather common in low grounds. The stems rise from 5 to 10 dm. and bear rather conspicuous racemes of flowers which are pale purplish marked with darker purple.

The fertilization of the perfect flower is well described by Foerste, in Am. Nat. XX, 66. It is proterandrous, as in other species of the genus. Foerste thinks that spontaneous self-fertilization occurs, and states that the visits of the bees seem to be less frequent than with most cross-fertilized Labiatæ.

The flowers project nearly horizontally. The tube is cleft on the upper side, so that even the lateral divisions of the upper lip form part of the lower lip. The stamens and style, therefore, are not protected as in the typical Labiates, but rise nearly upright and bend forwards. If the flowers were arranged in a nearly flat-topped inflorescence, as in *Pycnanthemum*, we would, no doubt, find them visited for honey and pollen by quite a miscellaneous set of insects. The form of the inflorescence, however, serves to offset some of the disadvantages in the structure of the flowers, for the stamens are protected by the flowers above them; so that it is not easy for insects to land directly upon them, and the lateral position of the flowers makes it inconvenient for the less specialized flower-insects to land upon them. This plant is gynodiœcious, the female form being much more common in my neighborhood.

I have found the flowers in bloom from June 24 to Aug. 13. On five days, July 6–10, I observed the following visitors, all sucking honey:—

Apidæ: (1) Apis melifica L. ☿, ab.; (2) Bombus virginicus Oliv. ☿; (3) Melissodes bimaculata Lep. ♂♀; (4) Magachile brevis Say ♀.

As far as observed the flowers of *Teucrium* are adapted to bees, and most of the species specially to bumble-bees, as shown in the following table. In some of the species the tube is so shortened as to admit mid-length or even short-tongued bees.

	BOMBUS.	OTHER BEES.	OTHER INSECTS.	TUBE IN MM.
Teucrium Scorodonia—Low Germany—Müller*	6	5	1	9–10
Pyrenees—MacLeod....	3	......	......	......
Chamædrys — Alps — Müller.........	3	1	1	7–10
Pyrenees — MacLeod..	2	......	......	......
Pyrenaicum — " "	4	......	......	......
Montanum — Alps — Müller..........	6	1	1	6
Scordium — Low Germany — Müller..	......	2	......	4
Botrys — " "	......	2	......	......
Canadense — Illinois................	1	3	......	6

Mentha Canadensis L.— The plant is common in wet places. The stem rises from five to ten dm., is much branched and bears in the axils of the leaves numerous whorls, each with many white flowers, whose lobes are faintly marked with purplish.

The flower has a form much as in *Lycopus*, the cleft upper lip appearing as an almost equal lobe of a four-lobed corolla. The slight irregularity has little significance, except as a trace of a former condition, for insects land indefinitely upon the flower clusters, approach the separate flowers from every side and receive the pollen on different parts of their bodies.

The plant is gynodiœcious. The hermaphrodite flowers are proterandrous. They expand about 3 by 5 mm., measure 5 or 6 mm. in length, the tube being about 3 mm. The anthers are exserted from 3 to 4 mm., the receptive stigma 5 mm. The female flower expands 3 or 4 mm., measures 4 or 5 mm. in length, the tube being about 3 mm. long. The anthers are imperfect and are included. The stigma is exserted about 2 mm.

* In the tables given in this paper, the observations of Müller in Low Germany are taken from his Fertilization of Flowers and Weitere Beobachtungen über Befruchtung der Blumen durch Insekten; those in the Alps from his Alpenblumen, ihre Befruchtung durch Insekten; those of MacLeod in the Pyrenees from DePyreneeënbloemen en hare Bevruchting door Insecten, Gent, 1891.

I have found the flowers in bloom from July 25 to Sept. 16. On seven days, Aug. 13–Sept. 16, I observed the following insects visiting the flowers for honey:—

Diptera — *Bombylidæ:* (1) Exoprosopa fascipennis Say; *Empidæ:* (2) Empis clausa Rob. (MS); *Syrphidæ:* (3) Tropidia quadrata Say; (4) Syritta pipiens L.; *Dexidæ:* (5) Rhynchodexia sp.; (6) Scotiptera parvicornis Twns. (MS); *Tachinidæ:* (7) Jurinia smaragdina Mcq., ab.; (8) J. apicifera Wlk.; *Muscidæ:* (9) Lucilia sylvarum Mg.; (10) L. cornicina F.

Hymenoptera — *Andrenidæ:* (11) Augochlora pura Say ♂; *Philanthidæ:* (12) Eucerceris zonatus Say; *Sphecidæ:* (13) Ammophila vulgaris Cr.; (14) A. gracilis Lep.; (15) Isodontia philadelphica Lep.; *Pompilidæ:* (16) Pompilus marginatus Say; *Scoliidæ:* (17) Myzine 6-cincta F.; (18) M. interrupta Say.

Lepidoptera — *Rhopalocera:* (19) Pieris rapæ L.; (20) Ancyloxypha numitor F.

Coleoptera — *Lampyridæ:* (21) Chauliognathus pennsylvanicus DeG.

At first I expected to find a preponderance of hymenoptera, but I found diptera more abundant. The most frequent visitor was *Jurinia smaragdina.* In showing a preponderance of species of diptera, my list agrees with the lists of European species observed by Müller and MacLeod, as shown in the following table:—

	DIPTERA.	HYMENOPTERA.	LEPIDOPTERA.	COLEOPTERA.		
Mentha arvensis — Low Germany — Müller....	11	4	1	....	....	16
aquatica — " "	18	5	...	....	....	23
sylvestris — Alps — Müller	8	5	3	....	....	16
Pyrenees — MacLeod	8	4	5	2	....	19
Canadensis — Illinois.................	10	8	2	1	....	21

Lycopus sinuatus Ell. — This species is common in wet places. The stems sometimes grow as tall as one metre, and are considerably branched. The flowers are arranged in axillary whorls.

The plant is gynodiœcious.* The corolla is white and

* According to Schulz, L. europæus bears female flowers — Beiträge zur Kentniss der Bestäubungseinrichtungen u. d. Geschlechtsvertheilung b. d. Pflanzen.

expands about 3 mm. It measures about 3 or 4 mm. in length, the tube 2 or 3 mm. The corolla, as in *Mentha*, is nearly equally four-lobed, the upper lobe being a little broader than the others, and the lower a little longer. The stigma is exserted about one mm. The hermaphrodite flowers are proterandrous, the anthers being exserted from one to two mm.

As far as noted, *Lycopus sinuatus* blooms from Aug. 5 to Sept. 16. On Aug. 13, 25 and Sept. 7, the following list of insects was observed, all only sucking except No. 4:—

Diptera — *Empidæ:* (1) Empis sp.; *Syrphidæ:* (2) Chrysogaster nitida Wd.; (3) Mesograpta marginata Say; (4) Syritta pipiens L., s. & f. p.; *Tachinidæ:* (5) Siphoplagia anomala Twns.; (6) Ocyptera euchenor Wlk.; (7) Trichopoda pennipes F.; (8) Jurinia smaragdina Mcq., ab.; *Dexidæ:* (9) Scotiptera parvicornis Twns. (MS); *Sarcophagidæ:* (10) Sarcophaga sp.; (11) Lucilia cornicina F.

Hymenoptera — *Apidæ:* (12) Apis mellifica L. ☿; (13) Bombus virginicus Oliv. ☿; *Andrenidæ:* (14) Prosopis affinis Sm. ♂; *Philanthidæ:* (15) Eucerceris zonatus Say; *Sphecidæ:* (16) Ammophila sp.; (17) Isodontia philadelphica Lep.; *Scoliidae:* (18) Myzine interrupta Say.

Lepidoptera — *Rhopalocera:* (19) Pholisora catullus F.

Coleoptera — *Lampyridæ:* (20) Chauliognathus pennsylvanicus DeG.

As in the case of *Mentha Canadensis*, the list shows a preponderance of diptera, in which it agrees with Müller's list of *L. europæus*, as shown in the table.

	DIPTERA.	HYMENOPTERA.	OTHER INSECTS.		
Lycopus europæus — Low Germany — Müller	6	1	3	....	10
sinuatus — Illinois	11	7	2	....	20

Pycnanthemum lanceolatum Ph. — The stems rise from 5 to 11 dm., the flowers being crowded in large flat-topped, compound inflorescences and being fertilized by insects which crawl about over them. In the Botanical Gazette, XIII, 154, Foerste gives a good account of the flowers, noting the proterandry, the little importance of the Labiate form and the great variety of insect visitors. The Labiate character of the

flowers has little importance, except as a record of a former condition. The flowers are erect or nearly so, and the lips are so widely expanded that the stamens are fully exposed and the tubes are about equally accessible from any side. Then the flat-topped inflorescence forms a most convenient resting-place for insects which would find great difficulty in visiting the flowers if they were widely separated.

From his observations on the American *P. lanceolatum* and *pilosum* in the Berlin garden, Dr. E. Löw * arrives at the erroneous conclusion that they are specially adapted to diptera. He found a plant with female flowers, from which it appears that the genus has gynodiœcious species. Later, Meehan records † the occurrence of gynodiœcism in *P. muticum.*

The tubular portion of the corolla is about 5 mm. long, and nectar rises in the tube so as to become accessible to tongues which cannot drain it. It blooms from July 14 to Sept. 7. July 31, the following list was observed, all the insects sucking: —

Hymenoptera — *Apidæ:* (1) Apis mellifica L. ☿, ab.; (2) Heriades carinatum Cr. ♀; (3) Cœlioxys 8-dentata Say ♀; (4) Epeolus remigatus F.; (5) E. lunatus Say ♀, freq.; (6) Calliopsis andreniformis Sm. ♂♀; *Andrenidæ:* (7) Nomia nortoni Cr. ♂; (8) Agapostemon radiatus Say ♂, ab.; (9) Augochlora lucidula Sm. ♂♀; (10) Halictus pectoralis Sm. ♀; (11) H. similis Sm. ♂; (12) H. parallelus Say ♀; (13) H. lerouxii Lep. ♂♀, (14) H. ligatus Say ♀; (15) H. faciatus Nyl, ♂♀, ab.; (16) H. confusus Sm. ♂♀, ab.; (17) H. stultus Cr. ♂, freq.; (18) Sphecodes arvensis Pttn. ♂♀, ab.; *Eumenidæ:* (19) Zethus spinipes Say; (20) Odynerus dorsalis F.; (21) O. arvensis Sauss.; (22) O. foraminatus Sauss.; *Crabronidæ:* (23) Oxybelus emarginatus Say; *Philanthidæ:* (24) Eucerceris zonatus Say, freq; (25) Cerceris fumipennis Say; *Sphecidæ:* (26) Ammophila procera Klug, ab.; (27) A. vulgaris Cr.; (28) A. pictipennis Walsh; (29) A. gracilis Lep.; (30) A. intercepta Lep.; *Scoliidæ:* (31) Myzine 6-cincta F.; (32) M. interrupta Say; (33) Scolia bicincta F.

Diptera — *Bombylidæ:* (34) Exoprosopa fasciata Mcq; (35) E. fascipennis Say; *Conopidæ:* (36) Zodion fulvifrons Say; (37) Oncomyia loraria Lw.; *Syrphidæ:* (38) Sphærophoria cylindrica Say; (39) Eristalis tenax L.; (40) Syritta pipiens L.; *Tachinidæ:* (41) Hyalomyia robertsonii Twns.; (42) Trichopoda pennipes F.; (43) Cistogaster occidua Wlk.; (44) Jurinia apicifera Wlk., ab.; (45) Acroglossa hesperidarum Will., freq.; *Muscidæ:* (46) Compsomyia macellaria F., freq.

* Beiträge z. Kentniss d. Bestäubungseinrichtungen einiger Labiaten, 1886.

† Proc. Acad. Nat. Sci. Phil., 1890.

Lepidoptera — *Rhopalocera:* (47) Pieris protodice B.-L.; (48) Phyciodes tharos Dru., freq.

Coleoptera — *Rhipiphoridæ:* (49) Rhipiphorus limbatus F.

Hemiptera — *Lygæidæ:* (50) Lygæus turcicus F.

Pycnanthemum muticum Pers. var. *pilosum* Gray. — Compared with the preceding, the plant is less abundant, has taller stems, 5 to 13 dm., and the inflorescences are hardly as attractive to insects, being somewhat smaller and less flat-topped. The tubes are about 6 mm. deep, only about one mm. deeper than in *P. lanceolatum*, but the result is that *P. muticum* shows more bees, compared with other hymenoptera, and an increase in large and long-tongued diptera. The plant blooms from July 5 to Aug. 15. July 29–31 I observed the following insects, all only sucking honey, except Nos. 17 and 18: —

Hymenoptera — *Apidæ:* (1) Apis mellifica L. ☿, ab.; (2) Bombus americanorum F. ☿; (3) Ceratina dupla Say ♀; (4) Megachile brevis Say ♀; (5) Epeolus lunatus Say ♂; (6) Calliopsis andreniformis Sm. ♂♀, freq.; *Andrenidæ:* (7) Agapostemon radiatus Say ♂, ab.; (8) Augochlora lucidula Sm. ♂♀; (9) Halictus pectoralis Sm. ♀; (10) H. similis Sm. ♂♀; (11) H. parallelus Say ♀; (12) H. lerouxii Lep. ♂♀, very ab.; (13) H. ligatus Say ♂♀, ab.; (14) H. fasciatus Nyl. ♂♀, ab.; (15) H. pilosus Sm. ♀; (16) H. zephyrus Sm. ♀; (17) H. confusus Sm. ♂♀, s. & c. p., ab.; (18) H. stultus Cr. ♀, s. & c. p., ab.; (19) Sphecodes mandibularis Cr. ♂; (20) S. arvensis Pttn. ♂♀; (21) Prosopis affinis Sm. ♀; *Eumenidæ:* (22) Odynerus foraminatus Sauss., ab.; (23) O. anormis Say; (24) O. sp.; *Crabronidæ:* (25) Crabro interruptus Lep.; (26) Anacrabro ocellatus Pack.; *Philanthidæ:* (27) Eucerceris zonatus Say; *Bembecidæ:* (28) Monedula carolina F.; *Sphecidæ:* (29) Ammophila procera Klug; (30) A. vulgaris Cr.; (31) A. intercepta Lep.; (32) A. pictipennis Walsh, freq.; (33) A. gracilis Lep., freq.; (34) Sphex ichneumonea L.; *Pompilidæ:* (35) Priocnemis fulvicornis Cr.; *Scoliidæ:* (36) Myzine sexcincta F., ab.; (37) M. interrupta Say; (38) Scolia bicincta F., ab.

Diptera — *Bombylidæ:* (39) Exoprosopa fascipennis Say, ab.; *Conopidæ:* (40) Physocephala tibialis Say; (41) Zodion fulvifrons Say; (42) Oncomyia loraria Lw.; *Syrphidæ:* (43) Eristalis tenax L.; (44) E. dimidiatus Wd.; (45) E. transversus Wd.; (46) Syritta pipiens L., ab.; *Tachinidæ:* (47) Hyalomyia purpurascens Twns.; (48) Trichopoda pennipes F.; (49) Cistogaster pallasii Twns.; (50) Jurinia smaragdina Mcq.; (51) J. apicifera Wlk., ab.; (52) Acroglossa hesperidarum Will.; (53) Siphona illinoensis Twns.; (54) Cuphocera ruficauda v. d. W.; *Sarcophagidæ:* (55) Sarcophaga sp.; *Muscidæ:* (56) Stomoxys calcitrans L.; (57) Lucilia cæsar L.; (58) Compsomyia macellaria F.

Lepidoptera — *Rhopalocera:* (59) Pieris protodice B.-L.; (60) Phyciodes tharos Dru.

Coleoptera — *Rhipiphoridæ:* (61) Rhipiphorus limbatus F.

Pycnanthemum linifolium Ph.—In my neighborhood this is the most common species of the genus. The stems are shorter than in *P. lanceolatum*, growing from 4 to 7 dm. high. The corolla tubes are a little shorter, about 4 mm. long. It was observed in bloom from June 29 to Sept. 12. July 19 and 20 I collected the following visitors, all only sucking, except No. 12:—

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, ab.; (2) Melissodes bimaculata Lep. ♂; (3) Ceratina dupla Say ♀; (4) Philerernus illinoensis Rob. ♀; *Andrenidae:* (5) Augochlora humeralis Pttn. ♀; (6) A. lucidula Sm. ♀; (7) A. pura Say ♀; (8) Halictus pectoralis Sm. ♀; (9) H. lerouxii Lep. ♂♀; (10) H. parallelus Say ♂♀; (11) H. fasciatus Nyl. ♂ ♀; (12) H. confusus Sm. ♀, s. and c. p.; (13) H. pruinosus Rob. ♂; (14) Sphecodes arvensis Pttn. ♀; (15) Prosopis affinis Sm. ♂♀; (16) P. pygmaea Cr. ♀; *Eumenidae:* (17) Odynerus arvensis Sauss.; (18) O. foraminatus Sauss.; *Crabronidae:* (19) Crabro interruptus Lep.; *Philanthidae:* (20) Eucerceris zonatus Say; *Bembecidae:* (21) Monedula ventralis Say; (22) M. 4-fasciata F.; *Sphecidae:* (23) Ammophila intercepta Lep.; (24) A. gracilis Lep.; (25) Pelopoeus cementarius Dru.: (26) Isodontia philadelphica Lep.; (27) Priononyx atrata Lep.; (28) P. thomae F.; *Pompilidae:* (29) Pompilus philadelphicus Lep.; (30) P. marginatus Say; (31) P. ferrugineus Say; *Scoliidae:* (32) Myzine sexcincta F.; (33) M. interrupta Say.

Diptera — *Midasidæ:* (34) Midas clavatus Dru.; *Bombylidæ:* (35) Exoprosopa fascipennis Say; *Empidæ:* (36) Empis clausa Rob. (MS); *Conopidæ:* (37) Conops brachyrrhynchus Mcq.; (38) Physocephala texana Will.; (39) Zodion fulvifrons Say; (40) Oncomyia loraria Lw.; *Syrphidæ:* (41) Chrysogaster nitida Wd.; (42) Mesograpta marginata Say; (43) Sphaerophoria cylindrica Say; (44) Eristalis latifrons Lw.; (45) E. transversus Wd.; (46) E. vinetorum F.; (47) Syritta pipiens L.; *Tachinidæ:* (48) Cistogaster occidua Wlk.; (49) C. pallasii Twns.; (50) Jurinia smaragdina Mcq.; (51) J. apicifera Wlk.; (52) Acroglossa hesperidarum Will.; *Muscidæ:* (53) Lucilia cornicinaF.; (54) Compsomyia macellaria F.

Lepidoptera — *Rhopalocera:* (55) Pieris rapae L.; (56) Colias philodice Godt.; (57) Phyciodes nycteis D.-H.; (58) Pyrameis huntera F.; (59) Lycaena comyntas Godt.

Coleoptera — *Scarabæidæ:* (60) Trichius piger F.; *Cerambycidæ:* (61) Typocerus sinuatus Newm.; *Mordellidæ:* (62) Mordella 8-punctata F.; (63) M. marginata Melsh.; *Rhipiphoridæ:* (64) Rhipiphorus flavipennis Lec., in cop.; (65) R. limbatus F., ab.

Hemiptera — *Lygaeidæ:* (66) Lygaeus turcicus F.; (67) Oncopeltus fasciatus Dall.

Pycnanthemum lanceolatum & linifolium — The following is a mixed list of insects taken from the flowers of both species and containing insects not mentioned in the lists of either of them: —

Hymenoptera — *Apidæ:* (1) Bombus separatus Cr. ♂☿; (2) B. pennsylvanicus DeG. ☿; (3) B. americanorum F. ♀; (4) B. virginicus Oliv. ☿; (5) Megachile inimica Cr. ♀; (6) M. latimanus Say ♂♀; (7) M. mendica Cr. ♂♀, ab.; (8) M. petulans Cr. ♂; (9) M. brevis Say ♂♀, ab.; (10) Alcidamea producta Cr. ♀; (11) Cœlioxys alternata Say ♂♀; (12) Epeolus fumipennis Say ♂; (13) Nomada texana Cr. ♀; *Andrenidæ:* (14) Halictus forbesii Rob. ♀; *Eumenidæ:* (15) Odynerus anormis Say; (16) O. sp.; *Crabronidæ:* (17) Crabro rufifemur Pack.; (18) Oxybelus frontalis Rob.; *Philanthidæ:* (19) Philanthus ventilabris F.; (20) Cerceris sp.; (21) C. finitima Cr.; *Bembecidæ:* (22) Megastizus brevipennis Walsh: (23) Bembex nubillipennis Cr.; (24) B. fasciata F.; *Larridæ:* (25) Astata unicolor Say; (26) Tachytes validus Cr.; *Sphecidæ:* (27) Sphex ichneumonea L.; (28) S. pennsylvanica L.; *Pompilidæ:* (29) Priocnemis fulvicornis Cr.

Lepidoptera — *Rhopalocera:* (30) Colias cæsonia Stoll; (31) Junonia cœnia Hüb.; (32) Thecla humuli Harr.; (33) Chrysophanus thoe B.-L.; (34) Pholisora catullus F.; *Ctenuchidæ:* (35) Scepsis fulvicollis Hub.

Diptera — *Bombylidæ:* (36) Anthrax fulvohirta Wd.; *Conopidæ:* (37) Conops xanthopareus Will.; (38) Physocephala tibialis Say.

Coleoptera — *Rhipiphoridæ:* (39) Rhipiphorus dimidiatus F.; *Curculionidæ:* (40) Centrinus scutellum-album Say.

Hemiptera — *Pentatomidæ:* (41) Euschistus ictericus L.; *Capsidæ:* (42) Calocoris rapidus Say — all sucking.

Hedeoma pulegioides Pers. — On stems which rise 1 or 2 dm. the pale-purplish flowers are arranged in small axillary clusters, one or two being open in each cluster at a time and being obscured by the abundant leaves.

The corolla measures about 7 or 8 mm., the tube 6, its narrow part 4. The lower lip, which is 3 lobed and expands about 3 mm., is marked with purple. The upper lip is straight, two-lobed and forms an imperfect helm. Two stamens alone are perfect, their anthers being exerted.

The flowers are imperfectly proterandrous or homogamous, and cross or self-pollination may occur.

The flowers are evidently adapted to small bees, and appear to depend mainly on *Calliopsis andreniformis* Sm. ♂♀, which is an abundant visitor. They are also visited by *Augochlora pura* Say ♀. The plant is common and blooms from Aug. 7 to Sept. 12.

Monarda Bradburniana Beck. — This horse-mint is common in "thickets, Illinois to Tennessee and Kansas," and with *Scutellaria parvula* is one of the earliest of Labiatæ,

blooming from May 17 to June 18. The plants are often collected in conspicuous patches. The stem rises 3 to 6 dm. and bears a large terminal head of pale purplish flowers.

The corolla is about 40 mm. in length and is divided for about half its length into strongly divergent lips. The upper lip is linear and measures about 20 mm. in length. Below, it is folded over the style and filaments; at tip it is provided with a beard the significance of which will be explained below. The lower lip is oblong and deeply channelled above — the groove forming a guide for the proboscides of the visitors. This lip is ornamented with purplish dots. The two anthers are situated under the tip of the upper lip, but are very feebly sheltered by it. The stigma is several mm. in advance of the anthers; its upper lobe is nearly aborted, the lower is long and curled downwards when receptive.

The flowers are proterandrous, but if the anthers retain some of their pollen until the stigma is receptive, spontaneous self-pollination is impossible on account of the wide separation of anthers and stigma. The flowers may be pollinated by insects with pollen from flowers of the same or of distinct plants.

The upper lip is slightly arched over the lower one; then the anthers, when dehiscent, and the stigma in turn when receptive, bend a little downwards so as to be more likely to touch the back of an insect settling upon the lower lip, but the lips still remain so strongly divergent that a consideration of the floral mechanism and the varying conditions in the relations of the visitors becomes exceedingly interesting.

At its origin, the upper lip is nearly perpendicular to the axis of the lower. Their tips are about 20 mm. or more apart. The dehiscent anthers and receptive stigma stand about 10 mm. above the highest part of the lateral edge of the lower lip. It is evident that only the largest insects are likely to touch these organs while resting upon the lower lip. The tube measures about 18 mm., its upper part being wide enough to admit the head of a bumble-bee for about 5 mm. This also indicates an adaptation to large insects with long tongues. The early blooming of the flower is also significant, for at this time the female bumble-bees, which are much larger than the

males and workers, are abundant, while the workers are just beginning to appear. Accordingly, I regard the flower as adapted to bumble-bee females, which in fact are the most abundant visitors. But butterflies and humming-birds are also frequent and are efficient pollinators. The visitors mentioned below were observed on 8 days, between May 19 and June 7:—

Apidæ: (1) Bomous separatus Cr. ♀, s., freq.; (2) B. americanorum F. ♀, s., ab.; (3) B. virginicus Oliv. ☿, s., one, rarely touching anthers and stigma; (4) B. ridiugsii Cr., ☿, s. and c. p., one.

Trochilidæ: (5) Trochilus colubris L.

Rhopalocera: (6) Pyrameis huntera F.; (7) Papilo philenor L.; (8) Pamphila zabulon B.-L., v. quadriquina Scud.; (9) P. metacomet Harr.; (10) Eudamus pylades Scud.; (11) E. bathyllus S.-A. — all sucking.

Now the tube, although 18 mm. deep, admits small bees for about 7 mm. and the nectar rises as high as 11 mm., so that small long-tongued bees can lower the nectar several mm., although not able to drain the tube. As a consequence, the nectar is often sought by small, or medium sized insects which never, or rarely, touched the anthers and stigma. Examples of such intruders are:—

(12) Apis mellifica L. ☿, s., ab.; (13) Ceratina dupla Say ♀, s. and c. p., ab.; (14) Coelioxys rufitarsis Sm. (=dubitata Sm.) ♀, s., one; (15) Bombylius atriceps Lw., s., ab.

In addition to these, a number of small bees visit the flower only for pollen, alighting directly upon the anthers or upon the tip of the upper lip, whose hairs serve them as a foot-hold while collecting pollen. These bees only find what they seek when the flower is in the male stage, but since they can hardly tell that the pollen is gone until they have landed, they are quite apt to visit the flowers which are in the female stage also. As they approach the tip of the lower lip from below and in front, they are apt to strike the stigma before they land. At any rate, I am satisfied that they often effect cross-pollination and that the hairs on the tip of the lip are increased in number and size for their benefit. The case is interesting, since it shows how the flower might be enabled to dispense with its nectar-visitors and depend upon its pollen-visitors—either if the nectar-visitors should become unnec

essary, or if they should become extinct, or rare, or should be drawn away by the competition of other flowers. The abundance of pollen-visitors is a result of the exposure of the anthers so that bees can land upon them or in a position convenient for reaching them. I think that *Verbascum* has become a synaemic pollen-flower as a result of exposing its anthers in such a way that they were sought so abundantly by pollen-insects that the nectar and the insects attracted by it became of no importance. To this third set of insects, in which *Ceratina dupla* (13) must be included, belong the following :—

(16) Calliopsis parvus Rob. ♀; (17) Augochlora pura Say ♀, ab.; (18) Halictus 4-maculatus Rob. ♀; (19) H. pectoralis Sm. ♀; (20) H. coriaceus Sm. ♀; (21) H. forbesii Rob. ♀; (22) H. confusus Sm., ♀, all c. p.; (23) Prosopis affinis Sm. ♂, f. p.

Finally, the flowers are perforated by *Odynerus foraminatus* Sauss., which being unable to obtain the nectar in a legitimate way, reaches it by cutting holes in the tube.

Monarda fistulosa * L. — The plant is very common, often growing in large patches along roadsides. It resembles the preceding, but is taller and much branched, the branches terminated by large heads, which rise to nearly the same level and render the plant quite conspicuous. The heads are smaller than in *M. Bradburiana*, about 45 mm. across, the flowers being of a uniform rose color.

The corolla measures about 30 mm. to the tip of the upper lip, the lower lip being about 12 mm. The upper lip is narrow, is continued directly upwards in line with the axis of the tube and seems to be of little or no value as a protection to the anthers and stigma, since these parts surpass its tip. The anthers and stigma stand 12 mm. distant from the lower lip and are hardly bent towards it, so that only the largest bees are likely to touch them when landing upon the lip.

On account of the erect position of the flowers, the exposure of the anthers and stigma, and the crowding of the flowers in an almost flat-topped cluster, the irregularity of the corolla

* See Foerste: Bot. Gaz. XIII, 154.

has little significance. Indeed, it seems that a return to complete regularity would not seriously disturb the present insect relations of the flower. Insects can land indefinitely upon the head, approach the flowers with equal convenience from almost any side, and can receive the pollen on almost any part of their bodies.

The tubes measure 18 or 19 mm., which indicates an adaptation to long tongues. The form of the tube, the bilabiate corolla, and the positions of the stamens and style indicate that the flower is a modification of a *nototribe* flower originally adapted to bumble-bees. The level-topped heads, the erect corollas, the exposed organs and the rose color indicates a tendency to suit butterflies, which in fact are the principal guests.

I have found the flowers in bloom from July 9 to Sept. 19. On 19 days, July 16 – Aug. 28, I observed the following visitors:—

Lepidoptera — *Rhopalocera:* (1) Papilio philenor L., ab.; (2) P. asterias F., ab.; (3) P. troilus L.; (4) P. cresphontes Cram.; (5) Colias philodice Godt.; (6) Danais archippus F.; (7) Argynnis cybele F.; (8) Limenitis disippus Godt.; (9) Pamphila zabulon B.-L.; (10) P. peckius Kby.; (11) P. otho S.-A., v. egeremet Scud.; (12) Pholisora hayhurstii Edw.; (13) Eudamus bathyllus S.-A.; (14) E. tityrus F.; *Sphingidæ:* (15) Hemaris thysbe F.

Birds — *Trochilidæ:* (16) Trochilus colubris L.

Hymenoptera — *Apidæ:* (17) Bombus vagans Sm. ☿; (18) B. americanorum F. ♂♀☿, ab.; (19) B. pennsylvanicus De G. ♂♀☿, ab; (20) B. separatus Cr. ♂, ab.; (21) Melissodes comanche Cr. ♂; (22) M. bimaculata Lep. ♀.

Diptera — *Bombylidæ:* (23) Exoprosopa fasciata Mcq., freq. — all sucking

In addition to the above, which visit the flowers only for nectar, which they obtain in a legitimate way, the flowers are sometimes sought by small bees in search of pollen, as in the case of *M. Bradburiana.* In this case I have observed: (24) Ceratina dupla Say ♀; (25) Halictus confusus Sm. ♀, ab.

The corollas are even more abundantly perforated by the same wasp, (26) Odynerus foraminatus Sauss., and by (27) O. dorsalis F. To obtain the nectar these wasps always cut new holes at the base of the tube, apparently never using the old holes. After this comes a lot of insects which do not cut holes themselves, but take advantage of the holes cut by

the *Odynerus*. In this category I have observed: (28) Apis mellifica L. ♀, ab.; (24) Ceratina dupla Say ♀; (29) Agapostemon radiatus Say ♀; (30) Augochlora pura Say ♀; (31) Halictus ligatus Say ♀; (32) H. lerouxii Lep. ♀; (33) H. fasciatus Nyl. ♀; (34) H. pilosus Sm. ♀; (25) H. confusus Sm. ♀; (35) Ammophila pictipennis Walsh.

Blephilia ciliata Raf. — The stems rise from 3 to 6 dm. and are simple, or sparingly branched, the stems and branches each bearing 3 or 4 head-like whorls, which measure about 3 cm. across.

The corolla is pale-purplish, the lower lip dotted with purple. The upper lip is narrow and commonly reflexed, forming a very imperfect helm. The lower lip is wider, 3-lobed, the middle lobe being long and narrow. The stamens are two, their anthers being exposed in the throat of the corolla. The anthers discharge their pollen before the stigma is receptive. The style becomes strongly exserted, holding the receptive stigma far beyond the upper lip. Sometimes plants are found having flowers with aborted anthers, which shows that the species is gynodiœcious.

On account of the exposure of the anthers and stigma and their close approximation, the flowers are so degraded that they have little advantage over regular, erect flowers. If these organs were protected, the flower would dust the back of each visitor in a very precise manner. As it is, insects crawl over the heads in an indefinite way, readily pollinating flowers which they do not visit. If the flowers were widely separated, insects like *Ammophila* would hardly visit them.

The corolla tube measures about 8 mm. and is, therefore, evidently adapted to long tongues, especially bees. On account of the exposed situation of the anthers, the flower is also visited for pollen by small bees which cannot drain the tubes, although they may reach some of the nectar which rises in them.

The plant is common in dry grounds and blooms from June 1 to July 3. On 8 days, between June 2 and 22, I collected the following visitors: —

Hymenoptera — *Apidæ:* (1) Apis mellifica L. ☿, s., ab.; (2) Bombus virginicus Oliv. ♀, s.; (3) B. americanorum F. ♀, s.; (4) B. pennsylvanicus DeG. ♀, s.; (5) B. separatus Cr. ♀, s.; (6) Ceratina dupla Say ♀, s. and c. p., ab.; (7) Megachile montivaga Cr. ♂, s., freq.; (8) M. brevis Say ♂♀, s. and c. p.; (9) M. mendica Cr. ♂♀, s.; (10) Alcidamea producta Cr. ♀, s. and c. p.; (11) Andronicus cylindricus Cr. ♂, s.; (12) Heriades carinatum Cr. ♀, s. and c. p., freq.; (13) Osmia distincta Cr. ♀, s.; (14) Cœlioxys 8-dentata Say ♂, s.; (15) Calliopsis andreniformis Sm. ♂♀, s.; *Andrenidæ:* (16) Agapostemon nigricornis F. ♀, s. and c. p., ab.; (17) Augochlora pura Say ♀, s.; (18) Halictus fasciatus Nyl. ♀, s. and c. p.; (19) H. pilosus Sm. ♀, s. and c. p.; (20) H. confusus Sm. ♀, s. and c. p., ab.; (21) H. stultus Cr. ♀, s. and c. p., freq.; *Sphecidæ* (22) Ammophila procera Klug., s., ab.; (23) A. intercepta Lep., s.; (24) A. pictipennis Walsh, s.; (25) Priononyx atrata Lep., s.

Lepidoptera — *Rhopalocera:* (26) Pieris protodice B.-L.; (27) P. rapæ L.; (28) Colias philodice Godt.; (29) Danais archippus F.; (30) Argynnis cybele F.; (31) Pamphila cernes B.-L.; (32) P. manataaqua Scud.; (33) P. verna Edw.; (34) Eudamus tityrus F. — all sucking.

Diptera — *Bombylidæ:* (35) Anthrax parvicornis Lw.; (36) Bombylius atriceps Lw., ab.; (37) Toxophora amphitea Wlk.; *Empidæ:* (38) Empis clausa Rob. (MS); *Tachinidæ:* (39) Jurinia smaragdina Mcq.; (40) Epigrimyia polita Twns. — all s.

Coleoptera -- *Scarabæidæ:* (41) Trichius piger F., s. and f. p., freq.

Blephilia hirsuta Benth. — This species closely resembles the preceding, but is less abundant, grows in damp woods, the stems being taller, 7 to 10 dm., more branched, the heads smaller, about 2 cm. wide and somewhat more widely separated. The flowers are white, the lower lip dotted with purple. The latter is expanded horizontally, with broad lateral lobes and a narrow median one. The upper lip is narrow and has lost its function as a helm, the anthers and stigma projecting far beyond it. At first the stamens hold the dehiscent anthers above the tip of the upper lip. After the pollen is discharged, they fall forwards, and the receptive stigma takes their place.

The flowers are often visited by bees which land upon the lower lip, suck the nectar in a legitimate way and receive the pollen upon their backs; but the exposure of the anthers and stigma makes it easy for bees to transfer the pollen by crawling over the heads in an indefinite way and sucking the flowers from any side, or even not sucking them at all. The exposure of the anthers makes it easy for small bees to collect the pollen, and they may do harm by neglecting the flowers in the

female stage, though they may pollinate them while crawling over the head in search of pollen.

As in *B. ciliata* the tubes are about 8 mm. long. On account of its shady situation, the plant is not so abundantly visited as in the preceding, and the list shows some peculiarities: viz., the scarcity of butterflies and the abundance of *Stylogaster*. On account of the later time of blooming — June 21 to Sept. 3 — the list shows males of *Bombus*, *Augochlora* and *Halictus*. On 7 days, between June 26 and July 21, I noted the following list: —

Hymenoptera—*Apidae:* (1) Apis mellifica L. ☿, s.; (2) Bombus virginicus Oliv. ♂, s.; (3) B. ridingsii Cr. ♂, s., freq.; (4) Ceratina dupla Say ♀, s. and c. p., ab.; (5) C. tejonensis Cr. ♂, s.; (6) Heriades carinatum Cr. ♀, s. and c. p.; *Andrenidae:* (7) Agapostemon nigricornis F. ♀, s., freq.; (8) A. radiatus Say ♀, s. and c. p.; (9) Augochlora pura Say ♂♀, s. and c. p.; ab.; (10) A. labrosa Say ♀, s.; (11) A. lucidula Sm. ♂, s.; (12) Halictus 4-maculatus Rob. ♀, c. p.; (13) H. pectoralis Sm. ♀, c. p.; (14) H. lerouxii Lep. ♂, s.; (15) H. pilosus Sm. ♀, s.; (16) H. stultus Cr. ♀, c. p., ab., (17) Prosopis affinis Sm. ♀, f. p.; *Sphecidae:* (18) Ammophila vulgaris Cr., s.

Diptera—*Empidae:* (19) Empis clausa Rob (MS); *Conopidæ:* (20) Stylogaster neglecta Will. s., very ab.; *Syrphidæ:* (21) Allograpta obliqua Say, f. p.; (22) Syritta pipiens L., f. p., sev.; *Muscidæ:* (23) Stomoxys calcitrans L., s.

Lepidoptera—*Rhopalocera:* (24) Pieris protodice B.-L.

Lophanthus nepetoides Benth. — The flower is figured and described by Foerste, in Am. Nat. XVIII., 928. The corolla is greenish-yellow. The stamens and style are exserted as far as 3 mm. beyond the corolla, so that the anthers and stigma are entirely unprotected by it. The stamens are strongly divergent. While the anthers are discharging pollen, the style is bent upwards, but afterwards it bends downwards, so as to hold the receptive stigma near the axis of the flower.

The stem and branches are terminated by close spikes in which the flowers are crowded. The flowers are visited by insects crawling over them, as Foerste has observed, and since the organs are exserted, the visitor is dusted indefinitely on all sides, and not on the back as would be the case if the flower had not lost its *nototribe* character.

On one occasion I found, at the summit of a spike, a flower with five stamens of equal length. The corolla showed

no sign of irregularity, except that one lobe, the lower, was a little longer than the other four. The ovary had four cells. The style was straight, holding the stigma directly over the center of the flower. The calyx was normal, but there was a well developed pedicel 2 mm. long. The flower had a slight inclination toward the lower petal.

The tube of the corolla is about 7 mm. long. The visitors consist mainly of bees. The plant is common, growing from one to two metres in height, and blooming from Aug. 4 to Sept. 22. On 7 days, between Aug. 7 and Sept. 2, I observed the following list: —

Hymenoptera — *Apidæ:* (1) Apis mellifica L. ☿, s., ab.; (2) Bombus vagau Sm. ♂, s., freq.; (3) B. virginicus Oliv. ☿, s. and c. p., ab.; (4) B. americanorum F. ♂☿, s. and c. p., ab.; (5) Melissodes bimaculata Lep. ♀, s.; *Andrenidæ:* (6) Augochlora labrosa Say ♀, s.; (7) Halictus confusus Sm. ♀, c. p.; (8) H. stultus Cr. ♀, c. p., ab.; *Sphecidæ:* (9) Ammophila iutercepta Lep., s.

Diptera — *Bombylidæ:* (10) Exoprosopa fasciata Mcq., s.; *Syrphidæ:* (11) Mesograpta geminata Say, f. p.; (12) Syritta pipiens L., s. aud f. p.

Lepidoptera — *Rhopalocera:* (13) Danais archippus F.; (14) Pieris rapæ L. — both s.

Plauts transferred from their normal habitat to the Berliu garden were found by Löw (1. c.) to be visited by *Coritus parumpunctatus* Schill. and *Lebirus biguttatus* L. He also found *L. rugosus* visited by *Apis mellifica*, *Bombus sp.*, *Eristalis tenax*, *Syritta pipiens* aud *Coritus parumpunctatus*.

Lophanthus scrophulariæfolius Benth. — This species agrees essentially with the preceding. The anthers are purplish and the corolla purplish tinged. The tubes are about 6 mm. long. Aug. 3 the following visitors were noted: —

Hymenoptera — *Apidæ:* (1) Apis mellifica L. ☿, s., freq.; (2) Bombus pennsylvanicus DeG. ☿, c. p.; (3) B. americanorum F. ☿, s. aud c. p.; (4) Megachile mendica Cr. ♀, s.

Diptera — *Bombylidæ:* (5) Exoprosopa fasciata Mcq., s., freq.

Nepeta Cataria L. — "Nat. from Eu." — The Catnip is common along road-sides and in waste-places. The stamens are tall, much branched, and the flowers are crowed in spike-like clusters. The flowers are proterandrous. The corolla tube is about 5 mm. deep, so that short-tongued bees can reach some of the nectar and those with mid-length tongues

can exhaust it. There is no list of the insects which visit it in its native country, Müller having observed only *Bombus muscorum* as a visitor.* It has succeeded in acquiring an efficient set in this country, as the following list indicates. It blooms from June 19 to Oct. 24. The list was made out on ten days, between June 26 and Sept. 10.

Hymenoptera — *Apidæ:* (1) Apis mellifica L. ☿, ab.; (2) Bombus virginicus Oliv. ☿; (3) B. americanorum F. ☿; (4) Melissodes bimaculata Lep. ♀; (5) Ceratina dupla Say ♀; (6) Megachile rufimanus Rob. ♂♀, ab.; (7) M. pugnata Say ♂; (8) M. relativa Cr. ♀; (9) M. infragilis Cr. ♂; (10) Alcidamea producta Cr. ♀; (11) Heriades carinatum Cr. ♀; (12) Nomada incerta Cr. ♀; (13) Calliopsis andreniformis Sm. ♀; *Andrenidæ:* (14) Agapostemon radiatus Say ♀; *Vespidæ:* (15) Odynerus fulvipes Sauss.; (16) O. foraminatus Sauss.

Diptera — *Bombylidæ:* (17) Anthrax parvicornis Lw.; *Tachinidæ:* (18) Jurinia smaragdina Mcq.; (19) J. apicifera Wlk.

Lepidoptera — *Rhopalocera:* (20) Pieris protodice B.-L.; (21) P. rapæ L. (22) Pyrameis atalanta L. — all sucking.

Nepeta Glechoma † Benth. (Glechoma hederacea L.) — "Nat. from Eu." — The flowers bloom before any of our native Labiates and, accordingly, show quite a peculiar set of visitors. The plant grows in damp woods, the stems being prostrate or procumbent. There are two or three blue flowers in the axils of the leaves, in which situation they are quite inconspicuous. The corolla approaches the typical Labiate form, the stamens and pistil being protected by a well developed galea. The pollen is dusted very definitely upon the tops of the heads of bumble-bee females, which are the normal visitors, or upon the upper part of the thorax of small bees. Butterflies occur as intruders, being quite uncertain to touch the anthers and stigma. The list shows a striking resemblance to the German list observed by Müller, the species being replaced by American species of the same genera. The genera *Synhalonia*, *Alcidamea*, and *Augochlora*, being American, could not occur as visitors in the normal habitat. Müller observed *Bombus* workers in Germany, but I observed only females. I have found only the female form, with tubes 8 or 9 mm. long.

* Alpenblumen.

† See Müller; Fertilization of Flowers.

The flowers are open from April 7 to June 21. On 6 days, between Apr. 28 and May 20, I observed as visitors: —

Hymenoptera — *Apidæ:* (1) Apis mellifica L. ☿, ab.; (2) Bombus vagans Sm. ♀; (3) B. ridingsii Cr. ♀; (4) B. americanorum F. ♀; ab.; (5) B. fervidus F. ♀, two, the only specimens I have seen here; (6) Anthophora abrupta Say ♂♀, ab.; (7) Synhalonia speciosa Cr. ♂♀, ab.; (8) Ceratina dupla Say ♂♀, ab.; (9) Alcidamea producta Cr. ♂; (10) Osmia albiventris Cr. ♀, freq.; (11) Nomada superba Cr. ♀, freq.; *Andrenidæ:* (12) Augochlora pura Say ♀; (13) A. lucidula Sm. ♀.

Diptera — *Bombylidæ:* (14) Bombylius atriceps Lw., ab.; *Syrphidæ:* (15) Rhingia nasica Say.

Lepidoptera — *Rhopalocera:* (16) Pieris rapæ L.; (17) Colias philodice Godt., ab.; (18) Pamphila zabulon B.-L.; (19) P. peckius Kby.— all sucking.

	Apis.	Bombus.	Anthophora.	Synhalonia.	Ceratina.	Alcidamea.	Osmia.	Nomada.	Andrena.	Halictus.	Augochlora.	Bombylius.	Rhingia.	Eristalis.	Lepidoptera.	Total.
Low Germany — Müller	1	11	1	..	..	..	3	1	3	1	.	2	1	1	4	28
Illinois	1	4	1	1	1	1	1	1	..	..	2	1	1	..	4	19

Scutellaria parvula Mx. — This is one of the earliest blooming of indigenous Labiates. The plants are scattered, or sometimes collected in thin patches. The stems rise 2 or 3 dm. The flowers are solitary in the axils of the opposite leaves, so that they appear in pairs. When several flowers are open at the same time they seem to be arranged in loose spikes.

The corolla measures about 9 mm., the tube being about 7 mm. and so wide above that it readily admits the head of a small bee for about 3 mm. The lower lip measures 5 mm. across and is directed downwards, forming the most attractive part of the flower. The corolla is blue, the lower lip being marked by a large squarish white spot dotted with purple and with streaks above leading into the throat.

The upper lip includes the lateral lobes. The upper lobe is only large enough to cover the anthers. The result is that the mode of pollen contact is of the most definite sort, the anthers touching the upper part of the bee's head and thorax. The lateral lobes are folded inwards under the anthers, so that a bee only touches them when the lateral lobes are

forced apart. This leaves the passage into the tube between the infolded lateral lobes and the lower one.

The anthers are approximated in pairs under the upper lip, the stigma occupying the interval between them. The foremost pair of anthers have only one cell, which is turned towards the receptacle. The outer cell is aborted, and the anther is turned so that the pollen-bearing cell is concealed. The aborted cell is bearded. When a bee enters, it strikes this anther and turns its face even further out of position for pollen contact, but when it withdraws, if it touches the beard, the anther is rotated downwards so as to bring the pollen surface in contact with the bee's body. This mechanism prevents the bee from carrying pollen back from the anthers to the stigma of the same flower. Consequently, if the bee enters with pollen from another flower, it will dust it upon the stigma before touching the pollen of the flower.

The flowers appear homogamous and are probably self-pollinated in absence of insects. They are adapted to small long-tongued bees, like *Ceratina* and *Alcidamea*. Butterflies are useless intruders, since they can drain the tubes without transferring pollen. The plants are common and bloom from May 20 to June 29. On 5 days, between May 19 and June 3, I observed as visitors: —

Hymenoptera — *Apidæ:* (1) Ceratina dupla Say ♂♀, s., ab.; (2) Megachile brevis Say ♂, s.; (3) Alcidamea producta Cr. ♂♀, s. and c. p., very ab.; (4) Osmia 4-dentata Cr. ♀, s.; (5) O. albiventris Cr. ♀, s. and c. p.; *Andrenidæ:* (6) Halictus pectoralis Sm. ♀, s.; (7) H. ligatus Say ♀, s.; (8) H. pilosus Sm. ♀, s.; (9) H. tegularis Rob. ♀, s., freq.; (10) H. pruinosus Rob. ♀, s., freq.;

Lepidoptera — *Rhopalocera:* (11) Ancyloxypha numitor F., s.; (12) Pamphila peckius Kby., s.; (33) Pholisora catullus F., s., freq.

Diptera — *Syrphidæ:* (14) Sphærophoria cylindrica Say, f. p.; (15) Syritta pipiens L., f. p.

Scutellaria canescens Nutt. — The stems are 6 to 12 dm. high and are terminated by a conspicuous flower-cluster formed by the closely collected racemes. The flower is like that of the preceding, but is much larger. The middle lobe of the upper lip is closely folded over the stamens and style, like the keel of *Papilionaceæ*. The flower is nearly closed, so that, when the bee forces an entrance, the galea is pushed upwards

and the organs are exposed. Afterwards, they return into the galea. The flowers are proterandrous. Two lateral lobes of the upper lip and two streaks on the lower are white, forming pathfinders. The tubes are about 14 mm. deep. The flower seems to depend mainly upon our common long-tongued bumble-bee, *Bombus americanorum* F. ☿, which visits it for honey and pollen. It is also visited for honey and pollen by *B. virginicus* Oliv. ☿, and for honey by *Exoprosopa fasciata* Mcq. and by *Pamphila zabulon* B.–L.

On Aug. 7, I noticed three little bees, *Augochlora pura* Say ♀, *Halictus confusus* Sm. ♀ and *H. stultus* Cr. ♀, sucking at holes near the base of the tube on one side. I suspected that the perforator was *Odynerus foraminatus* Sauss., the same insect which perforates the flowers of *Monarda fistulosa* and *Bradburiana* and *Pentstemon lævigatus*. After waiting awhile I was rewarded by seeing this wasp return to the plants and cut several new holes. As in the cases above, I only noticed the insect making new holes and not using the holes already made.

This plant was observed on 4 days, between Aug. 3 and 26. It is common and blooms from July 11 to Sept. 19.

Scutellaria versicolor Nutt. — The stems rise from 3 to 6 dm. and bear a few racemes of blue flowers. The lower lip is white dotted with purplish. The corolla is about 19 or 20 mm. long, its tube being narrow and measuring about 15 or 16 mm. Pollen is dusted upon the upper side of the bee's head. There are only a few flowers open on each plant at a time, so that, although crossing between flowers of the same plant may occur, it is much more likely to be between flowers of distinct plants. The flower is visited by *Anthophora abrupta* Say. It is common and blooms from June 20 to July 15.

Brunella (*Prunella*) *vulgaris* L. — " Fields and borders of copses, Newfoundland to Florida, and west to California and northward; evidently indigenous in some of the cooler districts. (Eu. Asia, Mex.) "— The flowers approach the typical form, the anthers being protected by the galea.

They are purplish and are arranged in a verticillastrate-spicate or capitate inflorescence. They are adapted to bumblebees, although often visited by other long-tongued bees and by butterflies. The plant blooms from July 6 to Oct. 9. On 8 days, between July 11 and Sept. 2, the following list was observed: —

Hymenoptera — *Apidæ:* (1) Bombus virginicus Oliv. ♂ ☿; (2) B. separatus Cr. ♂; (3) B. vagans Sm. ☿; (4) B. americanorum F. ☿, ab.; (5) Clisodon terminalis Cr. ♂ ♀; (6) Melissodes bimaculata Lep. ♀; (7) Ceratina dupla Say ♀; (8) Megachile mendica Cr. ♂ — all s.; *Andrenidæ:* (9) Augochlora pura Say ♀, s.; (10) Halictus fasciatus Nyl. ♀, c. p.; *Scoliidæ:* (11) Scolia bicincta F., s.

Lepidoptera — *Rhopalocera:* (12) Pieris rapæ L.; (13) P. protodice B. L.; (14) Colias philodice Godt.; (15) Pamphila peckius Kby.; (16) P. cernes B.-L.; (17) P. otho S. and A., var. egeremet Scud.; (18) Pholisora hayhurstii Edw. — all s.

Diptera — *Bombylidæ;* (19) Exoprosopa fasciata Mcq.; *Tachinidæ:* (20) Jurinia smaragdina Mcq. — both s.

The following table gives the results of the observation of *Brunella vulgaris* in widely separated localities: —

	Bombus.	Other Apidæ.	Andrenidæ.	Scoliidæ.	Butterflies.	Diptera.	
In Low Germany — Müller	4	3	3	....	5	....	15
On the Alps — Müller	5	....	....	....	10	1	16
On the Pyrenees — MacLeod	7	....	....	....	....	2	9
In Illinois	4	4	2	1	7	2	20

Physostegia Virginiana Benth. — This is by far the most handsome of the native Labiates, blooming from July 19 to Oct. 10. The stems rise from 5 to 10 dm., being terminated by one simple spike or by several spikes collected in a panicle. The flowers are cataleptic,* so that when turned in any direction they remain in the same position until disturbed. Prof. J. M. Coulter † has observed that this movement is of advantage in a driving rain by turning the mouths of the flowers away from the rain. As pointed out in the Bot. Gaz. XIII.,

* See Bailey: Bot. Gaz., VII., 122.
† *Ibid.* 111.

33, the movement is also of advantage in windy weather, since bees as a rule move against the wind and always turn with their heads towards it when alighting, so that the movement of the flowers turns them in such a position that the bees are most likely to be attracted by their odor and color, and can readily land upon them.

The flowers are rose or flesh-color, measure about 25 mm. long and, when collected in the spikes, make a splendid display. The Labiate form is somewhat modified by the enlargement of the mouth of the tube, which admits the head and thorax of a bumble-bee. The anthers and stigma are protected under the upper wall, and the pollen is dusted upon the upper part of the bee's thorax. The proterandry of the flower was first recorded by Delpino.*

The narrow part of the tube is about 9 mm. long. The flower is visited abundantly and almost exclusively by *Bombus americanorum* F. ♂♀☿. I have also seen it visited by single individuals of *Melissodes bimaculata* Lep. ♂, *Megachile brevis* Say ♂, *Danais archippus* F. and *Colias philodice* Godt. At Mt. Carmel, in Southern Illinois, according to Schneck, Bot. Gaz. XVI., 312, the flower is perforated by *Xylocopa virginica*. This bee is rare in my neighborhood; I have never seen but two individuals.

Marrubium vulgare † L.—"Nat. from Eu."—The corolla is white, the upper lip narrow and cleft, the lower three-lobed. The stamens are included in the corolla tube, so that they are out of reach of pollen-insects, and the pollen is applied to the insect's proboscis. The tube is about 5 mm. long.

In Germany, Müller found the flowers visited by 4 bees, 1 Chrysid, 1 Empis, 1 bug, 1 beetle. In the Pyrenees, MacLeod saw it visited by *Bombus terrestris*. The flowers bloom from May 28 to Oct. 5. June 22, 29, and Sept. 9, I observed the following visitors: —

Hymenoptera — *Apidæ:* (1) Apis mellifica L. ☿, ab.; (2) Bombus ameri-

* Ulteriori osservazioni.

† See Müller: Weit. Beobachtungen.

canorum F. ☿; (3) Ceratina dupla Say ♀; (4) Megachile brevis Say ♀, one.

Diptera — *Bombylidæ:* (5) Bombylius atriceps Lw.

Lepidoptera — *Rhopalocera:* (6) Pieris protodice B.-L., freq. — all s.

Leonurus Cardiaca L. — "Nat. from Eu." — This plant is common, growing along side-walks and road-sides. The stems rise 5 to 10 dm. and with the nearly erect branches, bear many whorls of flowers which appear as if arranged in a long leafy spike. Only a few flowers are open at a time in each whorl.

The corolla is whitish, the upper lip being pale purplish beneath and the lower being marked with brownish and purple. The lips are strongly divergent. The lower has the middle lobe folded and the lateral strongly reflexed. The upper lip is oblong and somewhat galeate, protecting the dehiscent anthers. Later, when the stigma becomes receptive, the upper lip is reflexed.

The flower is properly fertilized by bees in search of honey, and the pollen is applied to their backs. But small bees, like *Halictus*, collect the pollen, hanging to the strongly bearded upper lip while doing so. They no doubt neglect the flowers in the second stage, although they may sometimes effect pollination by alighting upon the style and stamens after the galea becomes reflexed. The flowers bloom from June 8 to Oct. 18. June 15 and 22 the following list of visitors was observed: —

Hymenoptera — *Apidæ:* (1) Apis mellifica L. ☿, s., ab.; (2) Anthophora abrupta Say ♂, s.; (3) Ceratina dupla Say ♀, s. and c. p., freq.; *Andrenidæ:* (4) Halictus fasciatus Nyl. ♀, c. p.; (5) H. confusus Sm. ♀, c. p., ab.; (6) H. stultus Cr. ♀, c. p.

Diptera — *Syrphidæ:* (7) Syrphus ribesii L.; (8) Mesograpta geminata Say; (9) Allograpta obliqua Say — all feeding on stray pollen.

At Wood's Holl, Mass., in July, Professor Trelease saw the flowers visited by (1) Apis mellifica L. ☿; (10) Bombus virginicus Oliv, ☿; (11) B. americanorum F. ☿; (12) Pieris rapæ L.

In Europe, where the plant is indigenous, Müller found it visited by Apis and four species of Bombus.*

* Weit. Beobachtungen and Alpenblumen.

Stachys palustris * L. — "Wet ground, Newfoundland to the Pacific in Oregon, south to Penn., and in the Rocky Mountain region to N. Mexico, north to Mackenzie River (Eu., N. Asia)" — The stem grows from2 to 10 dm. high. The flowers are arranged in whorls of six or more in the axils of the upper leaves, the uppermost whorls being approximated in loose spikes. Spikes of this kind terminate the stem and several branches, so that the flowers are rendered quite conspicuous and attractive to insects.

The corolla is pale purplish, measuring about 11 mm. long. The upper lip forms a well-developed helm, which serves as an efficient protection for the anthers. The helm is 4 mm. long and 3 mm. wide. The lower lip affords a convenient horizontal landing place about 6 mm. in extent, with large lateral lobes and a larger rounded middle one.

The flowers are proterandrous. In the first stage the flowers are less expanded, so that the visiting insects are more likely to touch the anthers. In the second stage the flower is more widely expanded, but then the receptive stigma is exserted considerably beyond the helm and is held down towards the lower lip in such a position that it is apt to touch a bee as it alights. From the mode of development of the flowers, visiting insects are most likely to approach the lower flowers first, proceeding upwards to those discharging pollen, which they carry in turn to the lower receptive flowers of the next spike.

Pollination may occur between different flowers of the same plant on different spikes. Cross-pollination occurs between distinct plants when the bee changes plants. I have not been able to satisfy myself that spontaneous self-pollination takes place, though Müller states that it does.

The flower shows the normal melittophilous form and function of the typical Labiates, although it is sometimes visited by flies and lepidoptera. On account of the protection of the helm, the pollen is not easily collected by *Halictus*, which neglect the flowers with receptive stigmas. It is accurately applied to the backs of insects sucking the honey. The tubes are from 6 to 8 mm. long, which indicates an adaptation to long

* See Müller: Fertilization of Flowers.

or mid-length tongues, but rather short tongues can reach the nectar by forcing their heads into the throat. The plant blooms from June 22 to Oct. 7. The visitors observed on 9 days, between June 23 and Aug. 29, are as follows: —

Hymenoptera—*Apidæ:* (1) Bombus americanorum F. ♂☿, s., freq.; (2) B. vagans Sm. ☿, s.; (3) Anthophora abrupta Say ♂, s.; (4) Melissodes bimaculata Lep. ♂♀, s., freq.; (5) Ceratina dupla Say ♀, s., ab.; (6) Meggachile brevis Say ♀, s., ab.; (7) Alcidamea producta Cr. ♀, s. and c. p., freq., (8) Calliopsis audreniformis Sm. ♂, s.; *Andrenidæ:* (9) Agapostemon nigricornis F. ♀, s.; (10) Halictus confusus Sm. ♀, c. p.

Lepidoptera—*Rhopalocera:* (11) Ancyloxypha numitor F.; (12) Pamphila cernes B.-L.; *Noctuidæ:* (13) Plusia simplex Gn., in the evening—all s.

Diptera—*Bombylidæ:* (14) Systœchus vulgaris Lw., s.; *Syrphidæ:* (15) Syrphus ribesii L., f. p.; (16) Mesograpta marginata Say, f. p.

	BOMBUS.	OTHER APIDÆ.	ANDRENIDÆ.	DIPTERA.	LEPIDOPTERA.	
Stachys silvatica — Low Germany — Müller...	3	3	....	2	....	8
Pyrenees — MacLeod.....	1	....	....	....	....	1
recta — Alps — Müller........	4	....	....	....	....	4
Low Germany "	....	2	....	....	....	2
Pyrenees — MacLeod......	2	....	....	....	1	3
Betonica — Low Germany — Müller...	3	3	....	2	5	13
palustris — " " " ...	4	1	....	2	3	10
Illinois..................	2	6	2	3	3	16

Review of the Labiatæ. — As in the case of *nototribe* flowers in general, I suppose that the form from which the original ancestor of the Labiatæ was developed was a regular horizontal gamopetalous flower in which insects were prevented from alighting upon the stamens by a tube which concealed them. The insects were thus required to land upon the lower border and to enter the flower on the lower side, touching the anthers and stigma with their backs and inserting their proboscides into the lower side of the tube. Consequently, the flower has become modified to suit an insect entering in this way. In the typical Labiate flower we find two lips, an upper one forming a helm protecting the anthers and stigma, and a lower forming a landing-place for visiting insects, as well as being the principal attractive organ. Below these is the contracted tube serving to lodge and conceal the nectar.

The ancestral type was probably melittophilous and has produced a most numerous set of species in competition with one another for the attention of bees. Competition between allied species is most severe. As a result of this strong competition we have many forms which have so far changed from the original type that they no longer come in competition for bees, but have become adapted to other kinds of insects. In the Fertilization of Flowers, 471, Müller says: "Delpino considers *Mentha* and *Coleus* Lour., degraded forms of the Labiate type; he, however, gives no reason for thinking them to be such, and not rather less specialized forms, differing less from the common ancestors of the Labiates." *Mentha* is one of the most ~~least~~ specialized of the family, and is specially adapted to flies. It is hardly to be expected that such a form would give rise to a large group of species nearly all of which are specially adapted to bees. Nor does it seem probable that small crowded erect flowers with exserted stamens would give rise to a multitude of flowers all of which had included stamens touching the insect's back. That *Mentha* is of a form approaching a simple regular flower is plain, but it seems to me to be a very different form from that of the original common ancester of the Labiates. It is rather a modification of a more irregular form, which I think will be more evident when we undertake to consider the forms in their divergence from the more characteristic form of Labiate flower.

It is difficult to find a flower which in its form and function realizes the type. Of those mentioned in this paper, perhaps *Scutellaria parvula* approaches the type as nearly as any, though it is probably too small. In this we have about two flowers open at a time on the leafy axis. Each flower is wholly independent of neighboring flowers. The lower lip is the main attractive part and invariably serves as a landing-place for small visitors. The anthers and stigma are concealed under the upper lip and always come in contact with the back of the insect. The nectar is concealed in a slender tube. The color is blue, with pathfinders, and the flower is adapted to bees.

The first condition which seems to be a departure from the

original type and readily to induce departures of a more serious nature is an aggregation of the flowers in a more or less close cluster. In this case the lower lip loses its distinctive function both as a vexillary organ and as a landing-place. Both offices are immediately assumed by the inflorescence itself. As long as the flowers remain separate, they attract the insects which are pleased by the special floral form and are adapted to it. But when the flowers become clustered they attract less specialized insects to what appears an undifferentiated color mass. In a similar way, separated flowers are only readily visited by insects to which the lower lip forms a convenient resting-place. But when the flowers form a compact inflorescence, a landing-place is formed by the flower-cluster. Even when the floral structure remains the same, I always expect to find less specialized insects on crowded flowers. As long as the cluster retains a spicate form, less specialized insects are not so well suited as when the inflorescence becomes flat-topped. In this case, these insects are afforded a convenient landing-place, and insects which would never notice a separate flower of the same form will rest with ease upon the broad horizontal platform afforded by the aggregated flowers.

But while the aggregation of the flowers is likely to induce the visits of less specialized insects, it makes easy other advantageous modifications correlated with the relief of the lower lip from its normal function. It permits a reduction in the size of the flower, or a contraction of its parts, with the result that the nectar may be more deeply concealed and the place of pollen-contact may become limited to the upper part of the bee's head or proboscis.

This specialization, however, is conditioned upon the retention by the galea of its normal function. For if the galea becomes reduced or reflexed in such a way as to expose the anthers and stigma, crowding results in changing the pollen-contact from the definite and precise *nototribe* style to the indefinite style characteristic of the least specialized regular flowers. If a Labiate flower typical in all other respects and separated from other flowers should come to have its anthers so exposed that insects could land upon them, it might be expected to change from *nototribe* to *sternotribe*, a

change which we may imagine has been thus produced in *Ocymum.* But exposure of the anthers and stigma in irregular crowded flowers is equally degrading both to those originally *nototribe* or *sternotribe*, — a proposition which I have already propounded in the Bot. Gazette XIII, 230.

In addition to being a most important organ in protecting the anthers and stigma and in preserving the original Labiate character of the flower, the galea, from its more or less horizontal position, also plays an important part in rendering the nectar less accessible. When, therefore, we find the flowers crowded in a flat-topped inflorescence, the upper lip reduced or reflexed in such a way as to expose the anthers and to render the nectar more accessible, we have the most degraded of the family and the form farthest removed from the type.

The fact that *Mentha* and *Pycnanthemum* have a more regular form than *Scutellaria* is no reason for supposing that it approaches the form from which the *Scutellaria* was derived. If a form like *Mentha* had its flowers exposed horizontally and separated so that each flower must be visited separately, I think it would result in *sternotribe* zygomorphism, like that of the *Papilionaceæ*, — a form almost always characterizing lateral flowers with exposed stamens. But I could hardly imagine any process by which closely crowded flowers with exposed organs would give rise to a group of flowers characterized by having the anthers protected under the upper wall of a deep tube. In the paper above referred to, I have expressed the view that small closely crowded regular flowers do not tend towards zygomorphism.

The modifications which we have considered have a most important influence in determining the kinds of insects frequenting the flowers of different species of the Labiatæ. There remains to be mentioned the varying length of the tube. In some species in which the general characters of the flower are of a low grade, a rather highly specialized set of visitors is retained as a result of a great lengthening of the tube, as in the case of *Monarda*.

In the table I have arranged the flowers as nearly as practicable in the order of their departure from the type, beginning with those which have a more perfect Labiate form, simpler

inflorescences and deep tubes and ending with those having exposed stamens, flat-topped inflorescences and short tubes. It will be observed that as the most distinct Labiate characters are lost there is an increase in the proportion of lower hymenoptera and diptera visiting the flowers. As the tubes shorten and as the galea becomes less efficient as a protecting organ, there is an increase in the number of *Andrenidæ* which visit the flower for nectar and for pollen. As we descend the list in the table, bees remain the predominant visitors until we reach *Monarda fistulosa* which shows a preponderance of butterflies. After we pass *Blephilia ciliata*, bees cease to be the predominant visitors, although the *Pycnanthemums*, except *P. linifolium*, show more bees than insects of other groups. Finally, the short tubed *Mentha* and *Lycopus* show lower hymenoptera in preponderance over bees, and flies more abundant than hymenoptera of any kind.

In the case of the Umbelliferæ, which have very uniform flowers, I have been able to show that the preponderance of bees, lower hymenoptera or diptera was determined mainly by the time of blooming, and the peculiarities in the lists of visitors were best shown by a table arranging the species in the order of blooming. A similar arrangement of the Labiatæ does not give very important results, since the differences in the lists are mainly due to differences in structure, and the time of blooming has little influence. In the case of the *Pycnanthemums*, there seems to be a plain case of correlation between the form and arrangement of the flowers and the time of flight of the lower hymenoptera, which are very important visitors. If the flowers bloomed in April, the lower hymenoptera would be almost entirely wanting, and the list would consist mainly of bees and flies.

Of the twenty-three species considered in the present paper, nine show long-tongued bees — *Bombus*, *Synhalonia*, *Anthophora* and *Melissodes* — as their principal visitors and depend mainly upon them. Eight show special adaptation to bees in general or to shorter-tongued species. Early blooming species are visited by *Bombus* females, *Anthophora*, *Synhalonia*, *Osmia* and *Alcidamea*. Later blooming species are vis-

ited by *Bombus* males and workers and *Melissodes*, while bees of the other genera are wanting.

No species is adapted to the lower hymenoptera, although 10 species were visited by them. They are important for only *Pycnanthemum*, *Mentha* and *Lycopus*. The Sphecidæ, especially *Ammophila*, are the most worthy of mention. *Ammophila* occurs as a visitor of 8 species — all after *Monarda*, except *Lophanthus scrophulariæfolius*.

Diptera occur as visitors of 19 species. Only two species, *Mentha* and *Lycopus*, are specially adapted to them. *Bombylius* occurs on four early blooming species, and *Exoprosopa* on 9 late-blooming ones, but they do not occur on the same species. Among *Tachinidæ* should be mentioned *Jurinia*, which visits 8 species.

Butterflies occur on all but five species. They are useful visitors of *Monarda Bradburiana*, and *M. fistulosa* is specially adapted to them. On other flowers they occur as intruders. *Papilio* was observed only on *Monarda*.

The ruby-throated humming-bird visits only *Monarda*. Another plant of the family, *Salvia splendens*, is specially adapted to humming birds.

Beetles occur only on the six least specialized flowers in the table. Species of *Rhipiphorus* seem to be quite fond of *Pycnanthemum*.

A few bugs occur on *Pycnanthemum*.

	BEES.	OTHER HYMENOPTERA	DIPTERA.	LEPIDOPTERA.	OTHER VISITORS.
Scutellaria versicolor	1				
canescens	2		1	1	
Physostegia Virginiana	3			2	
Nepeta Glechoma	13		2	4	
Brunella vulgaris	10	1	2	7	
Scutellaria parvula	10		2	3	
Marrubium vulgare	4		1	1	
Stachys palustris	10		3	3	
Teucrium Canadense	4				
Leonurus Cardiaca	8		3	1	
Nepeta Cataria	14	2	3	3	
Hedeoma pulegioides	2				
Monarda Bradburiana	15		1	6	1
fistulosa	8		1	15	1
Lophanthus nepetoides	8	1	3	2	
scrophulariæfolius	4		1		
Blephilia hirsuta	17	1	5	1	
ciliata	21	4	6	9	1
Pycnanthemum muticum var. pilosum	21	17	20	2	1
lanceolatum	18	15	13	2	2
linifolium	16	17	21	5	8
Mentha Canadensis	1	7	10	2	1
Lycopus sinuatus	3	4	11	1	1

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FLOWERS AND INSECTS — ROSACEAE AND COMPOSITAE.

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Mr J. H. Burkill
with compliments of
author.

FLOWERS AND INSECTS — ROSACEAE AND COMPOSITAE.

CHARLES ROBERTSON.

Contributions to an account of the mutual biological relations of the entomophilous flora and the anthophilous insect fauna of Macoupin County, Illinois.

PRUNUS AMERICANA L. — The trees grow a few metres high and are covered in early spring with a profusion of white flowers, which appear with the leaves. The corolla expands from 15 to 20 mm. When the corolla opens, the style with its stigma already receptive is exposed to insects, while the anthers are still closed. This gives abundant opportunity for cross-pollination between flowers of the same or of different trees. After the anthers begin to dehisce, cross-pollination is still readily effected by insects touching the stigma first. But insects coming without pollen may effect self-pollination. In case insect-visits fail, spontaneous self-pollination may occur in those flowers in which some of the stamens equal or exceed the style in length, by the flowers closing up so that the anthers may be thrown against the stigma, or turning horizontally, so that some of the pollen may fall upon the stigma. In many flowers, however, the stigma so far surpasses the anthers that spontaneous self-pollination is impossible. Nectar is secreted by the broad wall of the receptacular tube. The tube is somewhat contracted at the mouth and slightly obstructed by the bases of the filaments.

The flowers are in bloom from April 15 to May 5. They are visited mainly by bees and flies. The following visitors were noted on April 17, 26 and 27: —

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s. and c. p., ab.; *Andrenidae*: (2) Andrena sayi Rob. ♂ ♀, s. and c. p., freq.; (3) A. salicis Rob. ♂, s.;

(4) A. cressonii Rob. ♂, s.; (5) A. flavoclypeata Sm. ♂, s., freq.; (6) Halictus lerouxii Lep. ♀, s.; (7) H. zephyrus Sm. ♀, s.; (8) H. confusus Sm. ♀, s. and c. p.; (9) H. stultus Cr. ♀, s.; (10) Colletes inaequalis Say ♀, s.

Diptera — *Bombylidae:* (11) Bombylius major L. s.; *Syrphidae:* (12) Chrysogaster nitida Wd.; (13) C. ustulata Lw.; (14) Platychirus hyperboreus Staeg.; (15) Syrphus americanus Wd.; (16) S. ribesii L.; (17) Mesograpta geminata Say; (18) Sphaerophoria cylindrica Say; (19) Eristalis dimidiatus Wd.; (20) Helophilus similis Mcq.; (21) Brachypalpus frontosus Lw.—all f. p. and sometimes s.; *Tachinidae:* (22) Gonia frontosa Say, s.; *Sarcophagidae:* (23) Cynomyia sp., s.; *Muscidae:* (24) Lucilia caesar L., s.; (25) L. cornicina F., s.; *Cordyluridae:* (26) Scatophaga squalida Mg., f. p.

Lepidoptera — *Nymphalidae:* (27) Pyrameis atalanta L.; (28) P. huntera F.; *Noctuidae:* (29) Plusia simplex Gn.; (30) sp. — all sucking.

Coleoptera — *Chrysomelidae:* (31) Orsodachna atra Ahr., f. p.

Prunus serotina Ehrh. — The trees are filled with small racemes which bear numerous small white flowers. The flowers measure about eight millimetres across. When they open, the stigma, which is already receptive, exposes its broad surface above the anthers, which are still closed and are held down by the incurved stamens. Later the stamens turn outwards and discharge their pollen. Flowers which are imperfectly expanded show the anthers discharging their pollen so near to the stigma that self-pollination is insured. The receptacular tube forms a shallow cup, the inner wall of which secretes nectar. The nectar is readily accessible to short-lipped insects, the style and stamens forming a very trivial obstruction in the way of the guests.

This species blooms later than *P. americana*, April 25 – May 23, and has more exposed nectar. Its visitors are like those of *Crataegus*. May 7, 13, and 18, I noted as visitors :—

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s. and c. p., ab.; (2) Bombus americanorum F. ♀, s., freq.; (3) B. virginicus Oliv. ♀, s.; (4) B. separatus Cr. ♀, s.; (5) Synhalonia speciosa Cr. ♂, s.; (6) Ceratina tejonensis Cr. ♂, s.; (7) Nomada sayi Rob. ♀, s.; *Andrenidae:* (8) Andrena pruni Rob. ♀, s.and c. p., freq.; (9) A. sayi Rob. ♀, s. and c. p.; (10) A. cressonii Rob. ♂ ♀, s. and c. p., freq.; (11) A. flavo-clypeata Sm. ♀, s. and c. p., ab.; (12) A. nuda, Rob. ♀, s. and c. p.; (13) A. rugosa Rob. ♂, s.; (14) A. forbesii Rob. ♀, s. and c. p.; (15) A. claytoniae Rob. ♀, s. and c. p., freq.; (16) A. crataegi Rob. ♂, s.; (17) Halictus coriaceus Sm. ♀, s., freq.; (18) H. lerouxii Lep. ♀, s. and c. p., freq.; (19) H. fasciatus Nyl. ♀, s. and c. p.; (20) H. pilosus Sm. ♀, s. and c. p.; (21) H. cressonii Rob. ♀, s. and c. p.; (22) H. zephyrus Sm. ♀, s. and c. p.; (23) H. confusus Sm. ♀, s. and c. p., freq.; (24) H. stultus Cr. ♀, s. and c. p., freq.; (25) Agapostemon radiatus Say ♀, s.; (26) Augochlora lucidula Sm. ♀, s.; (27) A. similis

Rob. ♀, s. and c. p., freq.; *Vespidae:* (28) Polistes metricus Say, s. *Tenthredinidae:* (29) Dolerus sericeus Say, s.

Diptera — *Stratiomyidae:* (30) Stratiomyia quaternaria Lw., s.; *Empidae:* (31) Rhamphomyia sp., s.; *Conopidae:* (32) Myopa vesiculosa Say, s.; *Syrphidae:* (33) Pipiza pistica Will., s.; (34) Chrysogaster nitida Wd., s.; (35) Syrphus ribesii L., f. p.; (36) Sphaerophoria cylindrica Say, s.; (37) Myiolepta strigillata Lw., s.; (38) Eristalis aeneus F., s., freq.; (39) E. dimidiatus Wd., s.; (40) Syritta pipiens L., s.; *Tachinidae:* (41) Gonia frontosa Say, s.; *Sarcophagidae:* (42) Cynomyia sp., s.; (43) Sarcophaga sp., s.; *Muscidae:* (44) Calliphora erythrocephala Mg., s.; (45) Lucilia sp., s.; (46) L. caesar L., s.; (47) L. cornicina F., s.; (48) L. latifrons Schin., s.; *Anthomyidae:* (49) Chortophila sp., s.; *Cordyluridae:* (50) Scatophaga squalida Mg., s.

Lepidoptera — *Nymphalidae:* (51) Danais archippus F., s.; (52) Pyrameis huntera F., s.

Coleoptera — *Cerambycidae:* (53) Molorchus bimaculatus Say, s.

Spiraea aruncus L.—The flowers of this plant are said by Müller * to be devoid of honey, but I have seen insects sucking. If the flowers were destitute of nectar, the plants which bear only pistillate flowers, which of course supply no pollen, would not be visited by insects. This comes nearer to being a beetle-flower than any flower I have observed. Of the twenty-four species of insects taken on the flowers, fifteen are beetles. As far as observed the flowers bloom from June 6 to 16. June 7th and 10th, the following visitors were taken :—

Coleoptera — *Dermestidae:* (1) Anthrenus musaeorum L., ab.; (2) Cryptorhopalum haemorrhoidale Lec.; (3) C. triste Lec., ab.; (4) Orphilus glabratus F., freq.; *Cerambycidae:* (5) sp.; (6) Euderces picipes F., ab.; (7) Acmaeops directa Newm.; *Chrysomelidae:* (8) sp.; *Bruchidae:* (9) Bruchus hibisci Oliv.; *Mordellidae:* (10) Mordella marginata Melsh., ab.; (11-12) Mordellistena spp.; (13) M. biplagiata Heb.; *Curculionidae:* (14) Centrinus picumnus Hbst., ab.; (15) Coleop. sp.— all f. p. or s.

Hymenoptera — *Andrenidae:* (16) Andrena sp. ♀, s.; (17) A. rugosa Rob. ♀, s.; (18) A. crataegi Rob. ♀, c. p.; (19) A. cressonii Rob. ♀, s.; (20) Halictus stultus Cr. ♀, s.; (21) Prosopis affinis Sm. ♂ ♀, s. and f. p., freq.

Diptera—*Empidae:* (22) Empis distans Lw., s.; *Oscinidae:* (23–24) spp., s.

In his garden at Lippstadt Müller found the flowers to be visited by four beetles and five other insects.†

Rubus occidentalis L.— The flowers grow in quite inconspicuous clusters, and open in succession. They expand as

* Fertilization of Flowers, 224.

† See Table III.

wide as fifteen millimetres, but on account of the short and narrow petals they are far from showy.

The stigmas become receptive before the anthers dehisce. The stamens are numerous, but short, and the outer ones discharge their pollen first. There is an opportunity for cross-pollination, for self-pollination by insects, and for spontaneous self-pollination in absence of insects. But the inner and upper stigmas can hardly receive pollen except by insect aid.

The honey secreting ring between the outer pistils and inner stamens is more readily accessible than in *R. villosus*, on account of the stamens being shorter and less abundant.

I have seen the flowers visited by *Andrena bicolor* F. ♀, and *Odynerus anormis* Say.

Rubus villosus Ait. — The stems rise from one to two metres high and bear numerous white flowers, which expand horizontally from two to four centimetres.

When the flowers first open, the numerous stigmas are receptive while the anthers are still closed. At this time, and later, when the outer anthers are discharging their pollen, a bee entering the flower may readily effect cross-pollination. At the same time, insects coming without pollen may effect self-pollination. When the inner anthers dehisce, spontaneous self-pollination may occur, for the stamens far overtop the stigmas.

Nectar is secreted by a narrow ring between the base of the receptacle and the filaments. The nectar is entirely concealed and rendered quite deep-seated by the dense circle of numerous stamens.

On account of their large size and rather deeply-seated, concealed nectar, the flowers seem to be specially adapted to bumble-bees, which are in fact the principal and most efficient visitors, but smaller insects occur and may effect pollination, though by no means so readily.

The flowers were noted in bloom from May 11 to June 22, The following visitors were taken May 24 and 29: —

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s., freq.; (2) Bombus americanorum F. ♀, s., freq.; (3) B. pennsylvanicus DeG. ♀, s.; (4) Ceratina dupla Say ♀, s.; *Andrenidae:* (5) Andrena sayi Rob. ♀, c. p.; (6) A.

crataegi Rob. ♀, c. p.; (7) Halictus pectoralis Sm. ♀, c. p.; (8) H. fasciatus Nyl. ♀, c. p.; (9) H. stultus Cr. ♀, c. p.

Diptera — *Empidae:* (10) Empis distans Lw., s.; *Syrphidae:* (11) Syritta pipiens L., f. p.

Geum album Gmelin. — The stems grow about six decimetres high and bear scattered flowers, which have white petals and expand 18 or 20 millimetres.

The flowers are proterogynous. The outer anthers dehisce first. There is abundant opportunity for cross-pollination. Later, self-pollination by insect aid is possible. In case insects fail, the lower stigmas may receive pollen from the neighboring anthers.

Nectar is secreted by the portion of the disc on which the stamens are inserted.

The flowers are visited by small Hymenoptera and Diptera. I have noted them in bloom from June 20 to September 13. The insects mentioned in the following list were noted on the flowers on July 6 and 11: —

Hymenoptera — *Apidae:* (1) Phileremus illinoensis Rob. ♀, s.; (2) Calliopsis andreniformis Sm. ♂, s.; *Andrenidae:* (3) Halictus fasciatus Nyl. ♂, s.; (4) H. pilosus Sm. ♀, s.; (5) H. pruinosus Rob. ♀, s. and c. p.; (6) H. confusus Sm. ♀, s. and c. p.; (7) H. tegularis Rob. ♀, s.; (8) H. stultus Cr. ♀, s. and c. p.; (9) Augochlora similis Rob. ♂♀, s. and c. p.; (10) Prosopis pygmaea Cr. ♂, s.; *Eumenidae:* (11) Eumenes fraternus Say, s.; (12 and 13) Odynerus spp., s.; *Crabronidae:* (14) Crabro interruptus Lep., s.; *Philanthidae:* (15) Cerceris compacta Cr., s.; *Chrysididae:* (16) Hedychrum violaceum Brullé, s.

Diptera — *Syrphidae:* (17) Mesograpta marginata Say, s.; *Tachinidae:* (18) Ocyptera sp., s.; *Sarcophagidae:* (19) Sarcophaga sp., s.

Coleoptera — *Cerambycidae:* (20) Euderces picipes F., s.; *Mordellidae:* (21) Mordella marginata Melsh., s.

Hemiptera — *Corimelaenidae:* (22) Corimelaena pulicaria Germ., s.

Geum vernum Torr. & Gr. — A few stems from the same base rise three or four decimetres in height and bear small cymes of yellow flowers.

The flowers expand about six or seven millimetres, the petals, however, being quite small and inconspicuous. The concavity of the receptacular tube is filled by a globular head of pistils. Above, it is produced into a thin, many-lobed rim which separates the head of pistils from the stamens. The filaments are inserted in a groove lying between this rim and

the insertion of the petals and sepals. An outer circle of stamens has straight filaments and erect anthers. The anthers of this circle dehisce before the others. The stamens of the inner circle have their filaments inflected, the indehiscent anthers being held between the head of pistils and the raised edge of the receptacle.

Nectar is secreted and lodged in the groove near the bases of the filaments. The flowers are homogamous. Insects visiting the flowers may effect cross-pollination. The anthers of the outer circle do not readily come in contact with the stigmas. When those of the inner circle dehisce, they often touch the stigmas of the lower pistils, but most of the pistils can receive pollen only through the agency of insects.

I have seen the flowers visited for nectar and pollen by *Augochlora pura* Say ♀.

Fragaria virginiana Mill., *var.* illinoensis Gr. — The plants are commonly collected in small patches. The scapes rise from one to two decimetres high and bear a few white flowers which expand horizontally from 15 to 25 millimetres. The flowers are gynodioecious, the female flowers being smaller and bearing aborted stamens. The hermaphrodite flowers are proterogynous, and there is, accordingly, abundant opportunity for cross-pollination of these flowers. The anthers stand so directly over the stigmas that, when the pollen is discharged, self-pollination may be effected by insects or by the pollen falling upon the stigmas. Nectar is secreted by a narrow portion of the receptacle and is held between the bases of the filaments and the outer pistils. It is, therefore, only imperfectly concealed and can be obtained by small bees and flies. The principal visitors are bees of the genus *Halictus*. The list contains visitors observed May 15th: —

Hymenoptera — *Apidae:* (1) Synhalonia speciosa Cr. ♂, s.; (2) Ceratina dupla Say ♂, s.; (3) Nomada superba Cr. ♂, s.; *Andrenidae:* (4) Halictus ligatus Say ♀, s.; (5) H. fasciatus Nyl. ♀, s., freq.; (6) H. pilosus Sm. ♀, s.; (7) H. confusus Sm. ♀, s. and c. p., freq.; (8) H. tegularis Rob. ♀, s.; (9) Augochlora pura Say ♀, s.; (10) A. similis Rob. ♀, s. and c. p., ab.; (11) Prosopis affinis Sm. ♂, s.; (12) P. pygmaea Cr. ♀, s.

Diptera — *Syrphidae:* (13) Paragus bicolor F., s. and f. p., freq.; (14) Sphaerophoria cylindrica Say, s. and f. p.; (15) Tropidia mamillata Lw.;

Sarcophagidae: (16) Sarcophaga sp., s., freq.; *Muscidae:* (17) Lucilia sylvarum Mg., s.

Potentilla canadensis L.— Except in their yellow color and smaller size, the flowers bear a strong resemblance to those of *Fragaria*. The plants are common and are often collected in patches of considerable size. A few stems rise from the same base and are ascending or trailing. A single plant does not bear many open flowers at a time, since the flowers are single on axillary peduncles, and there is therefore an increased opportunity for cross-pollination between distinct plants.

The flowers expand horizontally about fifteen millimetres. Nectar is secreted on the narrow line between the outer pistils and the stamens. The pistils have their stigmas receptive before the anthers dehisce. In case cross-pollination does not take place oefore the pollen is discharged, self-pollination may occur by insect aid, or spontaneously by the pollen falling upon the stigmas.

The blooming time is from April 30 to June 17. The visitors mentioned below were taken on May 18 and June 2:—

Hymenoptera—*Apidae:* (1) Bombus americanorum F. ♀, s.; (2) Ceratina dupla Say ♂♀, s., freq.; (3) C. tejonensis Cr. ♂, s.; (4) Alcidamea producta Cr. ♂, s.; (5) Osmia albiventris Cr. ♀, s., (6) Stelis lateralis Cr. ♂, s.; (7) Nomada annulata Cr. ♂, s.; (8) N. sayi Rob. ♂, s.; *Andrenidae:* (9) Andrena ziziae Rob. ♂♀, s., ab.; (10) H. pectoralis Sm. ♀, s.; (11) H. ligatus Say ♀, s.; (12) H. fasciatus Nyl. ♀, s.; (13) H. confusus Sm. ♀, s.; (14) Augochlora pura Say ♀, s. and c. p., ab.; (15) A. similis Rob. ♀, s.; ab.; (16) Sphecodes mandibularis Cr. ♀, s.; (17) Prosopis affinis Sm. ♂, s.; *Eumenidae:* (18–20) Odynerus spp., s., freq.; (21) O. anormis Say, s.

Diptera—*Syrphidae:* (22) Paragus tibialis Fll.; (23) Syritta pipiens L., s.; *Tachinidae:* (24) sp., s.; (25) Cistogaster occidua Wlk., s.; *Sarcophagidae:* (26) Sarcophaga sp., s.; *Muscidae:* (27) Lucilia sp., s.; *Anthomyidae:* (28) Chortophila sp., s.

Lepidoptera—*Nymphalidae:* (29) Phyciodes tharos Dru., s.

Rosa humilis Marsh.— The flowers expand several centimetres. The stamens are turned outwards so strongly that insects landing near the center of the flower are likely to touch the stigmas before becoming dusted with pollen from the same flower. Nectar is wanting. The principal visitors are bumblebees and other large bees, which collect the pollen, and

a common beetle, *Trichius piger*, which feeds upon it. Small bees may collect the pollen without touching the stigmas.

The blooming time of *Rosa humilis* is from May 22 to July 8. *Anthophora abrupta* ♀, whose time of flight is from May 13 to the last of June, seems to depend for pollen almost exclusively upon this rose.

On twelve days, between May 22 and June 20, I observed the following visitors:—

Hymenoptera — *Apidae:* (1) Bombus virginicus Oliv. ☿; (2) B. americanorum F. ♀, ab.; (3) B. separatus Cr. ♀; (4) Anthophora abrupta Say ♀, ab.; (5) Synhalonia speciosa Cr. ♀; (6) Ceratina dupla Say ♀; *Andrenidae:* (7) Halictus confusus Sm. ♀; (8) Augochlora pura Say ♀; (9) Agapostemon viridula F. ♀ — all collecting pollen.

Coleoptera — *Scarabaeidae*: (10) Trichius piger F., ab.; *Chrysomelidae:* (11) Diabrotica 12-punctata Oliv.— both feeding on pollen.

Rosa setigera Michx. — The flowers resemble those of *Rosa humilis*, but the styles cohere in a column, which enables the stigmas to touch a visiting bumble-bee a little more readily. I have noted the flowers in bloom from June 16 to July 4. June 16 I saw them visited for pollen by (1) Bombus americanorum F. ♀; (2) Anthophora abrupta Say ♀; and (3) Trichius piger F.

Pyrus coronaria L. — During the blooming time — April 25 to May 16 — the trees are conspicuous with a profusion of rose-colored flowers. The attractiveness of the flowers is increased by their delicious fragrance.

The corollas expand from four to five centimetres. The receptacular tube extends nearly directly upwards from the ovary for a distance of about two millimetres. The summit of the tube is surmounted by a dense circle of filaments which are also directed upwards and a little inwards. In this way the nectar is effectually concealed and short-tongued and weak insects are excluded. The nectar is reached by a bee thrusting its proboscis between the separating ends of the filaments. The flowers are strongly proterogynous. In most of them the stigmas are protruded so far beyond the anthers, that spontaneous self-pollination after the anthers begin to dehisce is impossible.

The deeply concealed nectar, the rose color and the large size of the flowers suggest adaptation to bumble-bees, which are, in fact, the principal visitors. The stamens and styles project so far that small insects would be quite unlikely to effect cross-pollination. Bumble-bees clasp the whole bunch of stamens between their legs. On May 5, 9 and 12 I observed the following visitors:—

Apidae: (1) Apis mellifica L. ☿, s., freq.; (2) Bombus virginicus Oliv. ♀, s., ab.; (3) B. americanorum F. ♀, s., ab.; (4) B. pennsylvanicus DeG. ♀, s.; (5) B. separatus Cr. ♀, s., freq.; (6) Synhalonia speciosa Cr. ♂, s., freq.

Lepidoptera — *Nymphalidae:* (7) Danais archippus F., s., one; *Hesperidae:* (8) Nisoniades juvenalis F., s., one.

Crataegus coccinea L. v. mollis Torr. and Gray. — The flowers appear with the leaves, and the trees are fairly white with the numerous corymbs. The flowers expand about two and one-half centimetres.

When the flowers open, the stigmas are found to be receptive, while the anthers are still closed. Later, when the anthers dehisce, there is a chance for self-pollination, with or without insect aid. The stamens, however, form a circle somewhat distant from the styles.

In *Pyrus coronaria* we have observed that the superior, nectar-bearing portion of the receptacular tube is produced directly upwards, forming a tube, whose mouth is concealed by the approximated filaments.

In *Crataegus* this part of the tube is expanded into a concave disc, and the filaments have no effect in concealing the nectar, which is sought by numerous short-lipped insects. Some very small insects can obtain the nectar without rendering any service in return by aiding in pollinating the flower. In this form the nectar-bearing disc measures six millimetres across. The flowers have a disagreeable odor, and sometimes the discs of the older flowers turn purplish.

In 1893 I found the flowers in bloom from April 26 to May 16. Although the blooming time of the variety overlaps with that of the typical form, there is little opportunity for intercrossing of the two, since one is going out of bloom while the other is coming in and they are in the most favor-

able condition for insect visits at different times. May 5 and 9,* principally on the former day, I captured the following visitors: —

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s. and c. p., ab.; (2) Bombus americanorum F. ♀, s.; (3) Ceratina dupla Say ♂, s.; *Andrenidae:* (4) Andrena bicolor F. ♀, s.; (5) A. sayi Rob. ♀, s.; (6) A. cressonii Rob. ♂♀, s., freq.; (7) A. flavo-clypeata Sm. ♂♀, s., ab.; (8) A. rugosa Rob. ♂, s.; (9) A. forbesii Rob. ♀, s. and c. p.; (10) A. claytoniae Rob. ♂, s., freq.; (11) A. crataegi Rob. ♂♀, s., ab.; (12) Halictus arcuatus Rob. ♀, s.; (13) H. lerouxii Lep. ♀, s. and c. p., freq.; (14) H. cressonii Rob. ♀. s.; (15) H. zephyrus Sm. ♀, s. and c. p., ab.; (16) H. confusus Sm. ♀, s.; (17) H. stultus Cr. ♀, s. and c. p., ab.; (18) Augochlora pura Say ♀, s.; (19) Colletes inaequalis Say ♀, s.; *Vespidae:* (20) Vespa germanica F., s.; (21) Polistes metricus Say, s.; (22) P. pallipes Lep., s.; *Eumenidae:* (23) Odynerus tigris Sauss., s.

Diptera — *Conopidae:* (24) Myopa vesiculosa Say, s., ab.; *Syrphidae:* (25) Pipiza pistica Will.; (26) *Chrysogaster ustulata* Lw.; (27) Myiolepta strigillata Lw., freq.; (28) Eristalis dimidiatus Wd.; (29) Helophilus similis Mcq.; (30) Xylota fraudulosa Lw. — all s. and f. p.; *Tachinidae:* (31) Hyalomyia sp., s.; *Sarcophagidae:* (32) Cynomyia sp., s.; *Muscidae:* (33) Calliphora erythrocephala Mg., s.; (34) C. vomitoria L., s.; (35) Lucilia caesar L., s.; (36) L. cornicina F., s.; (37) Cyrtoneura sp., s.; *Anthomyidae:* (38) Chortophila sp., s.

Coleoptera — *Scarabaeidae:* (39) Euphoria fulgida F.; *Cerambycidae:* (40) Molorchus bimaculatus Say; *Chrysomelidae:* (41) Diabrotica vittata F.; *Oedemeridae:* (42) Asclera puncticollis Say — all s. or f. p.

Lepidoptera — *Nymphalidae:* (43) Grapta interrogationis F., s.

Crataegus coccinea L.—The flowers of this form agree in most essentials with those of the variety, but are more fragrant, smaller, grow in smaller cymes, and the nectar-bearing disc is more concave and narrow.

When the flowers open, the receptive stigmas are exposed above the anthers, which are still closed. The stamens are bent inwards over the disc. They turn outwards in succession, the outer ones discharging pollen first.

The flowers bloom from May 5 to 22. On the 9th and 12th, the following visitors were noted :—

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s. and c. p., freq.; (2) Bombus americanorum F. ♀, s., freq.; (3) B. virginicus Oliv. ♀, s.; (4) Ceratina dupla Say ♂, s.; (5) Nomada articulata Sm. ♂, s.; *Andrenidae:* (6) Andrena sayi Rob. ♀, s.; (7) A. perezi Rob. ♂, s.; (8) A. cressonii Rob.

* I did not find the flowers under favorable conditions for insect visits after this date.

263

♂♀, s.; (9) A. flavo-clypeata Sm. ♂♀, s. and c. p., ab.; (10) A. ziziae Rob. ♂, s., freq.; (11) A. rugosa Rob. ♂, s.; (12) A. claytoniae Rob. ♂, s., freq.; (13) A. crataegi Rob. ♂♀, s., ab.; (14) Halictus lerouxii Lep. ♀, s.; (15) H. ligatus Say ♀, s.; (16) H. fasciatus Nyl. ♀, s., freq.; (17) H. zephyrus Sm. ♀, s., freq.; (18) H. confusus Sm. ♀, s.; (19) H. stultus Cr. ♀, s.; *Vespidae:* (20) Polistes metricus Say, s., freq.; (21) P. pallipes Lep., s.; *Scoliidae:* (22) Tiphia inornata Say, s.

Diptera — *Empidae:* (23) Empis sp., s.; *Bombylidae:* (24) Bombylius major L., s.; *Conopidae:* (25) Myopa vesiculosa Say, s.; *Syrphidae:* (26) Pipiza pistica Will.; (27) Psilota buccata Mcq.; (28) Syrphus ribesii L.; (29) Mesograpta geminata Say; (30) Myiolepta strigillata Lw., freq.; (31) Eristalis aeneus F.; (32) E. dimidiatus Wd.; (33) Helophilus similis Mcq.; (34) Mallota cimbiciformis Fll. — all s. or f.p.; *Tachinidae:* (35) Gonia frontosa Say, s.; *Sarcophagidae:* (36) Cynomyia sp., s.; (37–38) Sarcophaga spp., s.; *Muscidae:* (39) Calliphora erythrocephala Mg., s.; (40) Lucilia sp., s.; (41) L. caesar L., s.; (42) L. cornicina F., s., freq.; (43) Compsomyia macellaria F., s.; (44) Cyrtoneura sp., s.

Coleoptera — *Coccinellidae:* (45) Hippodamea 15 — maculata Muls., s.; (46) Coccinella sanguinea L., s.; *Scarabaeidae:* (47) Euphoria fulgida F., s.; *Cerambycidae:* (48) Molorchus bimaculatus Say, s., freq., in cop.; *Chrysomelidae:* (49) Diabrotica vittata F., f. p.; *Oedemeridae:* (50) Asclera puncticollis Say., f. p.

Lepidoptera — *Nymphalidae:* (51) Danais archippus F., s.; (52) Pyrameis huntera F., s.

Crataegus crus-galli L.— This species resembles the preceding. The trees are even more conspicuous with the white blossoms. It blooms later — May 20 to June 1 — and consequently shows an increase in Aculeate Hymenoptera. With the exception of No. 8, which was taken on May 29, all of the visitors were observed May 22.

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s. and c. p., ab.; (2) Bombus virginicus Oliv. ♀, s.; (3) B. americanorum F. ♀, s.; (4) B. pennsylvanicus DeG. ♀, s.; (5) B. separatus Cr. ♀, s.; (6) Synhalonia speciosa Cr. ♂, s.; (7) Ceratina dupla Say ♂, s.; (8) Megachile infragilis Cr. ♂, s.; (9) Heriades philadelphi Rob. ♂, s.; (10) Panurgus (?) andrenoides Cr. ♀, s.; *Andrenidae:* (11) Andrena sp. ♀, s. and c. p.; (12) A. bicolor F. ♀, s. and c. p.; (13) A. sayi Rob. ♀, s. and c. p.; (14) A. cressonii Rob. ♂♀, s. and c. p., freq.; (15) A. flavo-clypeata Sm. ♂♀, s. and c. p., the most abundant visitor; (16) A. ziziae Rob. ♂♀, s. and c. p., ab.; (17) A. forbesii Rob. ♀, s. and c. p.; (18) A. claytoniae Rob. ♀, s. and c. p.; (19) A. crataegi Rob. ♂♀, s. and c. p., ab.; (20) Halictus gracilis Rob. ♀, s. and c. p., freq.; (21) H. pectoralis Sm. ♀, s. and c. p.; (22) H. fasciatus Nyl. ♀, s. and c. p., ab.; (23) H. pilosus Sm. ♀, s. and c. p.; (24) H. zephyrus Sm. ♀, s. and c. p.; (25) H. confusus Sm. ♀, s. and c. p., ab.; (26) H. stultus Cr. ♀, s. and c. p., ab.; (27) H. tegularis Rob. ♀, s. and c. p., freq.; (28) Augochlora similis Rob. ♀, s. and c. p., freq.; (29) Colletes inaequalis Say ♀, s. and c. p.; (30) Prosopis sp. ♂, s.; (31) P. affinis Sm. ♂♀, s., ab.;

(32) P. pygmaea Cr. ♂♀, s., ab.; *Vespidae:* (33) Polistes metricus Say, s.; *Eumenidae:* (34) Eumenes fraternus Say, s., freq.; (35) Odynerus walshianus Sauss., s.; (36) O. tigris Sauss., s.; (37) O. capra Sauss., s.; (38) O. foraminatus Sauss., s.; (39) O. anormis Say, s.; *Crabronidae:* (40) Crabro scutellatus Say, s.

Diptera — *Stratiomyidae*: (41) Stratiomyia discalis Lw., s.; *Syrphidae*: (42) Chrysogaster nitida Wd.; (43) Didea fasciata fuscipes Will.; (44) Xanthogramma emarginata Say; (45) Mesograpta geminata Say; (46) Volucella vesiculosa F.; (47) Eristalis dimidiatus Wd.; (48) E. latifrons Lw.; (49) E. transversus Wd.; (50) Helophilus similis Mcq.; (51) Mallota cimbiciformis Fll.; (52) Syritta pipiens L. — all s. or f. p.; *Sarcophagidae:* (53) Cynomyia sp., s.; (54) Sarcophaga sp., s.; *Muscidae:* (55) Cyrtoneura sp., s.; (56) Lucilia sp., s.; (57) Lucilia caesar L., s.; *Anthomyidae:* (58-59) Chortophila spp.; *Ortalidae:* (60) Camptoneura picta F., s.

Coleoptera — *Buprestidae:* (61) Acmaeodera culta Web., s.; *Scarabaeidae:* (62) Euphoria fulgida F., s.; *Cerambycidae:* (63) Molorchus bimaculatus Say, s.

Lepidoptera — *Nymphalidae:* (64) Danais archippus F.; *Lycaenidae:* (65) Lycaena pseudargiolus B. — L.; *Papilionidae:* (66) Papilio philenor L. — all s.

Amelanchier canadensis Torr and Gr. — This is the earliest of the indigenous Rosaceae — blooming from April 1 to 27. In my neighborhood the small trees grow on high creek banks and are fairly white with the numerous flowers, which appear before the leaves. The flowers are crowded in short racemes terminating the branches. The oblong petals measure 12 or more mm. in length and are so closely interwoven with the petals of neighboring flowers that the more inconspicuous flower-stalks and calyces are concealed, and the outlines of the individual flowers are lost in the white mass. Nectar is secreted by that portion of the receptacular tube which lies between the ovary and the bases of the filaments. When the flower opens, the five styles, with their receptive stigmas, are exposed above the inflected stamens, whose anthers are still closed. The stamens straighten and turn outwards in succession, the anthers discharging their pollen in the same order. Five innermost stamens remain strongly inflected, with their large closed anthers obstructing the mouth of the tube until all of the other anthers have become emptied. The flowers are abundantly visited, and until the anthers dehisce, there is full opportunity, in all favorable weather, for the stigmas to receive pollen from other flowers of the same or of distinct trees. If such pollination does not

occur early, there is provision for spontaneous self-pollination, for by the closing of the petals at night, or in cloudy or rainy weather, the anthers of some of the longer stamens come in contact with the stigmas.

The flowers are pollinated by bees principally of the genus *Andrena*. On April 10th and 11th, I noted as visitors: —

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s. and c. p., ab.; (2) Bombus ridingsii Cr. ♀; (3) Ceratina dupla Say ♂; *Andrenidae:* (4) Andrena sayi Rob. ♂♀, freq.; (5) A. salicis Rob. ♀; (6) A. illinoensis Rob. ♀; (7) A. cressonii Rob. ♂♀; (8) A. flavoclypeata Sm. ♂♀, ab.; (9) A. rugosa Rob. ♂; (10) A. forbesii Rob. ♀, freq.; (11) A. mariae Rob. ♂; (12) A. claytoniae Rob. ♂; (13) Halictus gracilis Rob. ♀; (14) H. pilosus Sm. ♀; (15) H. zephyrus Sm. ♀; (16) H. caeruleus Rob. ♀; (17) H. confusus Sm. ♀; (18) H. stultus Cr. ♀ — all sucking; *Tenthredinidae:* (19) Dolerus arvensis Say, s.

Diptera — *Syrphidae:* (20) Mesograpta marginata Say; (21) M. geminata Say; (22) Sphaerophoria cylindrica Say; (23) Eristalis aeneus F.; *Tachinidae:* (24) Phorocera edwardsii Will.; *Muscidae:* (25) Lucilia cornicina F. — all sucking.

Review of the preceding Rosaceae: — In table I the plants are given as nearly as practicable in the order in which they were observed, beginning with those blooming first. Little needs to be said of *Geum vernum* and *Rubus occidentalis*, which are sparingly visited by insects.

Spiraea aruncus strikes us as the most peculiar, since it shows a strong preponderance of Coleoptera. Beetles occur on nine species, but are not very important except in case of *Spiraea*.

Four species show a strong preponderance of bees. These are *Pyrus coronaria*, *Rubus villosus*, *Rosa humilis* and *setigera*. These are large flowers, forming a firm support for heavy insects, and requiring large insects readily to pollinate them. The two former have the nectar more deeply concealed than usual, so that it is only accessible to long tongues. The *Andrenidae* which I noted on *Rubus villosus* were only collecting pollen. The roses have no nectar, but yield abundant pollen, and are the largest and most attractive of all the flowers. These four species may be regarded as humble-bee flowers, though they are also less frequently visited by other large bees.

The other flowers have the nectar so situated that it is convenient for short-tongued insects, and these flowers agree in showing a preponderance of *Apidae*, *Andrenidae* and *Diptera*. Early in the spring the anthophilus insect-fauna consists mainly of these insects. Later in the season bees and flies come in competition with the lower Aculeate Hymenoptera, which become abundant. Accordingly, these insects show a larger proportion on the late flowering *Geum album* than on any other species. The earlier species show quite a number of bees of the genus *Andrena*. The time of flight of all of these species of *Andrena* is over before *Geum album* comes in bloom, and, consequently, the list of visitors shows none of them. *Andrenas* would be expected to occur on *Fragaria*, and probably do, but my list is quite fragmentary. Müller found one *Andrena* on *F. vesca*.

The usual colors of the Rosaceae are white (13 species, table II.) or yellow (5 cases), colors characterizing flowers adapted to miscellaneous insects. *Pyrus* and *Rosa* show marked departures from the ordinary colors, and, as noted above, are adapted to bumble-bees.

Except in the cases of the species adapted to *Apidae*, these bees are not very abundant on the flowers. Of the *Apidae* which fly throughout the season, we have *Apis* and *Ceratina*. *Bombus* females occur on the early species, and the workers appear later on *Rosa*. On the earlier flowers we find the early flying species, such as *Anthophora*, *Synhalonia*, *Osmia*, *Nomada* and *Panurgus?* Later species show *Phileremus*, *Stelis* and *Calliopsis*.

The flowers being of rather simple structure, with easily accessible nectar and numerous exposed stamens, are particularly well suited for the short-tongued bees — *Andrenidae*. These consist mainly of *Andrena* and *Halictus*. Early blooming species show the single early *Colletes inaequalis*. A little later we find *Agapostemon*, *Augochlora*, *Prosopis* and *Sphecodes* — a few species of each. The males of *Halictus*, and the allied genera *Agapostemon* and *Augochlora*, do not appear until late in the season. Accordingly, the early lists show nothing but females of these genera, and we find males of *Halictus* and *Augochlora* only on the late flowers of *Geum album*.

In table II. I have arranged the species which I have thus far found in my neighborhood (Carlinville, Ill.— 39° 21′), in the order in which they appear. At the bottom of the table we have the whole reduced to a curve for the *Rosaceae*. The parts of the table which seem to me the most defective are those giving the blooming periods of *Rubus*, *Rosa*, *Spiraea* and *Gillenia*. When these are more completely worked out, I think the curve will become more regular, giving a more evident maximum for May and June.

Amelanchier canadensis blooms first and almost entirely escapes competition, *Prunus americana* being the only competitor. The latter overlaps with the later period of the former and with the early part of the period of *P. serotina* and *Fragaria*. In May we have a time of strong competition. At the same time we have *Prunus serotina*, *Fragaria*, *Pyrus*, *Geum vernum*, *Crataegus coccinea* v. *mollis* and *C. coccinea*, and *Potentilla canadensis*. *Pyrus coronaria* avoids competition by attracting bumble-bees. *Geum vernum* seems to have the worst of the struggle and shows a strong tendency to avoid competition for the attention of insects by resorting to spontaneous self-pollination. *Potentilla canadensis* shows a strong disposition to overcome the disadvantage of this strong competition by lengthening its blooming time and extending it until the others have gone out. As far as other members of the order are concerned, the struggle for existence seems to favor the later blooming of this plant.

The three *Crataegi* have a sharp struggle among themselves. The severity of this contest is relieved by var. *mollis* coming first. *C. coccinea* fills the gap between the former and *C. crus-galli*. There is no rivalry between the first and the last.

In the period from the middle of May to the middle of June, competition is not so strong, though quite a number of species are in bloom at the same time. Pressure between *Rubus* and *Rosa* is relieved by the fact that the former is visited for nectar and the latter only for pollen. There must be a strong contest between *Rubus villosus* and *canadensis*, though the former seems to be earlier. *R. occidentalis* seems to incline to self-pollination, though it is visited by shorter-lipped insects. Among the roses, *R. humilis* is earliest, but my observations here are not complete.

Among the *Bombus*-flowers, *Pyrus* has everything its own way, while the contest is weak between *Rubus* and *Rosa*, but strong between the congeners of these genera.

In June *Spiraea* seems to depend upon beetles without being molested by its relatives. *Gillenia*, from its structure, seems to depend mainly upon small, long-tongued bees, but I hope to pay more attention to it next season.

Geum album is practically without competition, except with *Potentilla norvegica*, and *Agrimonia eupatoria* and *parviflora*. *Agrimonia eupatoria* was observed by Müller * to be visited for pollen by nine *Syrphidae*, one *Anthomyia* and one *Halictus*. I have yet to make observations on this species and *A. parviflora*.

Potentilla norvegica seems to depend mainly upon self-pollination. Its long blooming time may to some extent, compensate for its inconspicuousness and its inability to attract numerous insects at any given time. This species and *Agrimonia eupatoria* are the only species treated of here which are credited by the Manual to both this country and Europe. From its long blooming time it resembles an introduced species.

Tables III. and IV. give the results of the observation of the insect-visitors of the genera considered in this paper. The observations in Low Germany were taken from Müller's Fertilization of Flowers and Weitere Beobachtungen über Befruchtung der Blumen durch Insekten; those in the Alps from his Alpenblumen, ihre Befruchtung durch Insekten und ihre Anpassungen an Dieselben. The observations made in the Pyrenees are taken from MacLeod: De Pyreneeënbloemen en hare Bevruchting door Insecten, eene bijdrage tot de bloemengeographie.

COMPOSITAE.

The following paper on the insect visitors of the Compositae gives the results of observations made in the neighborhood of Carlinville, Illinois. Since hardly half of the species growing here are included, I have thought it better to withhold a general review of the family until at least most of the remaining species have been studied.

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* Fertilization of Flowers, 235.

269

In connection with plants having so many insect visitors it will be well to acknowledge the sources from which I have received aid. Early in my work Mr. E. T. Cresson kindly named my bees. Later I have determined them myself from descriptions, and through the kindness of Mr. Cresson have compared doubtful cases with the types in the collection of the American Entomological Society. I have worked up the local species of Andrenidae, and described the species which seemed to be new. Mr. W. H. Ashmead has kindly determined my Chalcididae, Braconidae and Ichneumonidae, though many of the Chalcids were determined by Mr. L. O. Howard. As regards the other Hymenoptera, I am responsible for the determinations, except in the case of a few species determined by Mr. Wm. J. Fox.

As regards the Diptera, Dr. S. W. Williston has identified most of the Bombylidae, Conopidae and Syrphidae, besides many other species of different families. Mr. D. W. Coquillett has determined the Empidae, etc., and Mr. C. H. T. Townsend most of the Tachinidae. Many Diptera I have lately determined for myself. Prof. G. H. French has aided me in the determination of Lepidoptera, Mr. P. R. Uhler and Mr. C. A. Hart have determined the Hemiptera. The Coleoptera were determined by Mr. Hart, except a few sent to Mr. Samuel Henshaw. In the more important anthophilous groups, I make it a rule to verify all determinations made for me, by comparison with the descriptions, whenever these are accessible.

Finally, I am indebted to Mr. Cresson for the interest he has always taken in the entomological part of my work, and to Prof. Wm. Trelease for friendly advice and kind encouragement as well as aid in gaining access to literature.

fasciculata Michx.

VERNONIA ~~NOVEBORACENSIS Willd.~~ — The stems are tall, and terminated by numerous heads arranged in a cyme. The heads are discoid. The florets are purple and have tubes nine or ten millimetres long. Pollen is carried out on the long hairy styles.

The visitors consist of long-tongued bees and flies, and butterflies. The flowers were observed in bloom from July

30 to September 26. On eight days, between August 17 and September 2, the following guests were noted: —

Hymenoptera — *Apidae:* (1) Bombus americanorum F. ♂♀, s., ab.; (2) B. pennsylvanicus DeG. ☿, s.; (3) B. separatus Cr. ♂, s.; (4) Melissodes perplexa Cr. ♂♀, s. and c. p., freq.; (5) M. obliqua Say ♀, s. and c. p.; (6) M. bimaculata Lep. ♂, s.; (7) Ceratina dupla Say ♀, s.

Lepidoptera — *Rhopalocera:* (8) Danais archippus F.; (9) Papilio turnus L.; (10) Pieris rapae L.; (11) Colias philodice Gdt., ab.; (12) Pamphila cernes B. — L.; (13) P. manataaqua Scud.; (14) P. metacomet Harr.; (15) Eudamus tityrus F. — all s.

Diptera — *Bombylidae:* (16) Exoprosopa fasciata Mcq., ab.; (17) Systoechus vulgaris Lw. — both s.

Eupatorium purpureum L. — The purplish color of the florets and the slender tubes seem to indicate an adaptation to butterflies, but the flowers are also visited by long-tongued Hymenoptera and Diptera.

The flowers bloom from August 4 to September 3. The list of visitors was observed August 4, 6–8: —

Lepidoptera — *Rhopalocera:* (1) Danais archippus F.; (2) Phyciodes nycteis D. — H., (3) Papilio philenor L.; (4) P. turnus L.; (5) Pieris rapae L.; (6) P. protodice B. — L.; (7) Colias philodice Gdt.; (8) Pamphila peckius Kby.; (9) Pholisora hayhurstii Edw. — all s.

Hymenoptera — *Apidae*: (10) Apis mellifica L. ☿; (11) Bombus pennsylvanicus DeG. ☿; (12) B. virginicus Oliv. ☿, freq.; (13) Melissodes bimaculata Lep. ♀; (14) M. aurigenia Cr. ♂; *Vespidae:* (15) Polistes rubiginosus Lep.; *Sphecidae:* (16) Ammophila gryphus Sm. — all s.

Diptera — *Bombylidae:* (17) Exoprosopa fasciata Mcq.; (18) Systoechus vulgaris Lw. — both s.; *Syrphidae:* (19) Volucella vesiculosa F., f. p.

Eupatorium serotinum Michx. — This is a common species, blooming from August 16 to Sept. 19. The tubes are shorter and broader than in *E. purpureum*, and consequently there are many more short-tongued species on the flowers. The following list was observed on August 24, 25, 27, 28, and September 19: —

Hymenoptera — *Apidae*: (1) Apis mellifica L. ☿, s. and c. p., ab.; (2) Bombus virginicus Oliv. ♂ ☿, s. and c. p., freq.; (3) B. vagans Sm. ♀, s. and c. p.; (4) B. scutellaris Cr. ♂, s.; (5) Megachile brevis Say ♂, s.; (6) Heriades carinatum Cr. ♂♀, s. and c. p., freq.; *Andrenidae:* (7) Agapostemon viridula F. ♂, s.; (8) Halictus pectoralis Sm. ♂, s.; (9) H. coriaceus Sm. ♂ ♀, s.; *Vespidae:* (10) Vespa germanica F.; (11) Polistes metricus Say; *Eumenidae:* (12) Eumenes fraternus Say; (13) Odynerus sp.; (14) O.

campestris Sauss.; *Crabronidae:* (15) Thyreopus tumidus Pk.; *Philanthidae:* (16) Cerceris fulvipes Cr., freq.; *Larridae:* (17) Ancistromma distincta Sm., ab.; *Sphecidae:* (18) Ammophila vulgaris Cr.; (19) A. intercepta Lep.; (20) Pelopoeus cementarius Dru.; (21) Isodontia philadelphica Lep.; *Pompilidae:* (22) Pompilus sp.; *Scoliidae:* (23) Myzine sexcincta F.; (24) Scolia bicincta F.—all s.

Diptera—*Bombylidae:* (25) Anthrax alternata Say; (26) Sparnopolius fulvus Wd.; (27) Geron senilis F.; *Conopidae:* (28) Physocephala tibialis Say; *Syrphidae:* (29) Chrysogaster nitida Wd.; (30) Chilosia sp.; (31) Eristalis tenax L.; (32) Spilomyia longicornis Lw.; *Dexidae:* (33) Prosena sp.; *Tachinidae:* (34) Gymnosoma fuliginosa R. D.; (35) Wahlbergia arcuata Say; (36) Jurinia smaragdina Mcq.; (37) Acroglossa hesperidarum Will.; (38) Loewia nigrifrons Twns.—all s.

Lepidoptera—*Rhopalocera:* (39) Eudamus tityrus F.; *Heterocera:* (40) Carmenta pyralidiformis Wlk.—det. by French; (41) Scepsis fulvicollis Hbn.; (42) Feltia subgothica Steph.; (43) Spragueia leo Gn.—all s.

Coleoptera—*Lampyridae:* (44) Chauliognathus pennsylvanicus DeG., s.; *Scarabaeidae:* (45) Euphoria sepulchralis F., s.; *Cerambycidae:* (46) Cyllene robiniae Forst., f. p.; (47) C. decorus Oliv., f. p.; *Rhipiphoridae:* (48) Rhipiphorus limbatus F., s.

EUPATORIUM PERFOLIATUM L.—Visitors observed on August 13, 25 and September 3:—

Hymenoptera—*Apidae:* (1) Apis mellifica L. ☿; *Andrenidae:* (2) Prosopis affinis Sm.; *Crabronidae:* (3) Crabro interruptus Lep., freq.; (4) Oxybelus frontalis Rob.; *Philanthidae:* (5) Eucerceris zonatus Say; *Sphecidae:* (6) Pelopoeus cementarius Dru.; *Scoliidae:* (7) Myzine interrupta Say, ab.—all s.

Diptera—*Empidae:* (8) Empis sp., s.; *Tachinidae:* (9) Cistogaster occidua Wlk.; (10) Siphophagia anomala Twns.—all s.

Coleoptera—*Meloidae:* (11) Epicauta pennsylvanica De G., f. p.; *Rhipiphoridae:* (12) Rhipiphorus limbatus F., s.

EUPATORIUM AGERATOIDES L.—Visitors observed September 2, 10, 12:—

Hymenoptera—*Apidae:* (1) Apis mellifica L. ☿, s. and c. p., ab.; *Andrenidae:* (2) Halictus ligatus Say ♂♀, s., freq.; (3) H. fasciatus Nyl. ♂, s.; (4) Augochlora pura Say ♀, s.; *Vespidae:* (5) Vespa maculata L., s.; *Eumenidae:* (6) Odynerus tigris Sauss., s.; *Larridae:* (7) Ancistromma distincta Sm., s.; *Scoliidae:* (8) Scolia bicincta F., s.

Diptera—*Bombylidae:* (9) Exoprosopa fasciata Mcq.; *Syrphidae:* (10) Allograpta obliqua Say; *Tachinidae:* (11) Cistogaster occidua Wlk.; *Dexidae:* (12) Rhynchodexia sp.; *Muscidae:* (13) Lucilia cornicina F.—all s.

Lepidoptera—*Lycaenidae:* (14) Lycaena pseudargiolus B.—L.; *Ctenuchidae:* (15) Scepsis fulvicollis Hbn.—both s.

LIATRIS PYCNOSTACHYA Michx. — The plants grow on prairies and are often collected in conspicuous patches. The stems rise from eight to sixteen decimetres high and bear long spikes of heads, each one of which contains five or six rose-purple flowers.

All of the flowers are perfect. Pollen is carried out and exposed on the long divisions of the style. The corolla tubes are from seven to eight millimetres long. The visitors are long-tongued bees and flies, and butterflies. By far the most abundant visitor observed by me is *Exoprosopa fasciata*.

Liatris pycnostachya blooms from July 21 to August 14. The following visitors were observed on August 9 and 10:—

Hymenoptera — *Apidae:* (1) Bombus americanorum F. ♂☿, s. and c. p., freq.; (2) B. virginicus Oliv. ☿, s. and c. p.; (3) B. separatus Cr. ♂ ☿, s., freq.; (4) Melissodes coloradensis Cr. ♂, s.; (5) M. obliqua Say ♂♀, s. and c. p., freq.; (6) M. aurigenia Cr. ♂♀, s., freq., (7) Ceratina dupla Say ♀, s., freq.; (8) Megachile latimanus Say ♂♀, s., freq.; (9) M. inimica Cr. ♀, s. and c. p.; (10) Epeolus remigatus F. ♂♀, s.; *Andrenidae:* (11) Halictus ligatus Say ♀, c. p., freq.; (12) Agapostemon viridula F. ♂♀, s., freq.

Lepidoptera — *Rhopalocera:* (13) Danais archippus F.; (14) Argynnis idalia Dru.; (15) Pieris rapae L.; (16) Colias philodice Gdt., freq.; (17) Papilio asterias F.; (18) P. philenor L.; (19) Pamphila peckius Kby., freq.; (20) P. cernes B.—L., freq.; (21) P. metacomet Harr.; (22) Eudamus tityrus F.; *Ctenuchidae:* (23) Scepsis fulvicollis Hbn.— all s.

Diptera — *Bombylidae:* (24) Exoprosopa fasciata Mcq., very ab.; (25) Systoechus vulgaris Lw.; *Conopidae:* (26) Physocephala texana Will.; (27) Stylogaster biannulata Say — all s.

SOLIDAGO MISSOURIENSIS Nutt.— Visitors observed on August 9, 17, 19:—

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s., one; (2) Melissodes obliqua Say ♀, s. and c. p., freq.; (3) M. perplexa Cr. ♀, s. and c. p.; (4) Ceratina dupla Say ♂, s.; *Andrenidae:* (5) Halictus pectoralis Sm. ♀, s. and c. p.; (6) H. ligatus Say ♀, s. and c. p., ab.; (7) H. fasciatus Nyl. ♀, s.; (8) H. confusus Sm. ♂♀, s. and c. p., freq.; (9) H. albipennis Rob. ♀, s. and c. p.; (10) H. tegularis Rob. ♀, s. and c. p.; (11) Augochlora similis Rob. ♀, s.; (12) Prosopis pygmaea Cr. ♀, s., freq.; *Vespidae:* (13) Polistes pallipes Lep., s.; *Eumenidae:* (14) Eumenes fraternus Say, s.; (15) Odynerus arvensis Sauss., s., freq.; (16) O. vagus Sauss., s.; (17) O. anormis Say, s.; *Crabronidae:* (18) Crabro interruptus Lep., s.; (19) C. chrysarginus Lep., s.; (20) Oxybelus frontalis Rob., s.; *Philanthidae:* (21) Philanthus ventilabris F., s.; (22) Eucerceris zonatus Say, s.; (23) Cerceris

compacta Cr., s., *Larridae:* (24) Ancistromma distincta Sm., s., freq.; *Sphecidae:* (25) Ammophila vulgaris Cr., s.; (26) A. intercepta Lep., s.; (27) A. pictipennis Walsh, s.; (28) Sphex pennsylvanica L., s.; (29) S. ichneumonea L., s.; (30) Priononyx thomae F., s.; *Scoliidae:* (31) Myzine sexcincta F., s., ab.; (32) M. interrupta Cr., s.; (33) Scolia bicincta F., s.; *Chrysididae:* (34) Hedychrum violaceum wiltii Cr., s., ab.; *Chalcididae:* (35) Perilampus cyaneus Brullé, s.; *Braconidae:* (36) Microdus simillimus Cr., s.; *Ichneumonidae:* (37) Ceratosoma fasciata Cr., s., freq.

Diptera — *Bombylidae:* (38) Exoprosopa fascipennis Say, freq.; *Syrphidae:* (39) Syritta pipiens L.; *Tachinidae:* (40) sp.; (41) Gymnosoma fuliginosa R. D.; (42) Siphoplagia anomala Twns.; (43) Miltogramma cinerascens Twns., freq.; (44) M. argentifrons Twns.; (45) M. flavicornis Twns.; (46) Gymnoprosopa clarifrons Twns.; *Dexidae:* (47) Scotiptera sp.; *Sarcophagidae:* (48) sp.; (49) Sarcophaga sp. — all s.

Coleoptera — *Lampyridae:* (50) Chauliognathus pennsylvanicus DeG., f. p.; *Chrysomelidae:* (51) Diabrotica 12-punctata Oliv., f. p.; *Meloidae:* (52) Epicauta pennsylvanica DeG., f. p., and gnawing, very ab. and destructive; *Rhipiphoridae:* (53) Myodites fasciatus Say, s.

Hemiptera — *Lygaeidae:* (54) Lygaeus turcicus F., s.

Solidago canadensis L.*— Visitors — August 8, 25, 27, September 15, 18, 23, 26, 30, October 3, 7, and 10: —

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s. and c. p., ab.; (2) Bombus virginicus Oliv. ♂ ☿, s. and c. p., freq.; (3) B. vagans Sm. ♂, s.; (4) B. americanorum F. ♂ ☿, s., ab.; (5) B. scutellaris Cr. ♂ ☿, s.; (6) B. separatus Cr. ♂ ☿, s., freq., (7) Melissodes sp., s. and c. p.; (8) M. desponsa Sm. ♀, c. p.; (9) M. perplexa Cr. ♀, s. and c. p.; (10) Heriades carinatum Cr. ♀, s.; (11) Caliopsis solidaginis Rob. ♀, s. and c. p.; *Andrenidae:* (12) Andrena solidaginis Rob. ♀, s. and c. p., ab.; (13) Halictus coriaceus Sm. ♀, s. and c. p.; (14) H. forbesii Rob. ♀, s. and c. p.; (15) H. ligatus Say ♀, s. and c. p.; (16) H. lerouxii Lep. ♀, s.; (17) H. confusus Sm. ♂, s., ab.; (18) H. albipennis Rob. ♀, s. and c. p.; (19) Colletes americana Cr. ♂ ♀, s. and c. p., ab.; (20) C. spinosa Rob. ♀, s. and c. p.; (21) C. compacta Cr. ♀, s.; (22) Prosopis affinis Sm. ♀, s. and f. p., ab.; *Vespidae:* (23) Polistes metricus Say, ab.; (24) P. annularis L., ab.; (25) P. pallipes Lep., ab.; (26) P. rubiginosus Lep.; *Eumenidae:* (27) Eumenes fraternus Say; (28) Odynerus tigris Sauss., ab.; (29) O. capra Sauss., ab.; (30) O. catskillensis Sauss.; (31) O. arvensis Sauss.; (32) O. foraminatus Sauss.; (33) O. anormis Say; (34) O. sp.; *Crabronidae:* (35) Crabro 10-maculatus Say; (36) C. interruptus Lep.; *Mimesidae:* (37) Mimesa denticulata Pk.; *Philanthidae:* (38) Eucerceris zonatus Say; (39) Cerceris fulvipes Cr., freq.; (40) C. clypeata Dlb.; (41) C. finitima Cr.; (42) C. compacta Cr.; *Larridae:* (43) Ancistromma distincta Sm., freq.; (44) Tachysphex acuta Pttn.; *Sphecidae:* (45) Ammophila vulgaris Cr.; (46) Pelopoeus cementarius Dru.; (47) Isodontia philadelphica Lep.; (48) Sphex ichneumonea L.; (49) S. pennsylvanica L.;

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* See Müller: Fertilization of Flowers, 321, & Weitere Beobachtungen III, 92.

(50) Priononyx thomae F.; (51) P. atrata Lep.; *Pompilidae:* (52) Pompilus relativus Fox; (53) P. sp.; (54) P. subviolaceus Cr.; (55) P. biguttatus F.; (56) P. marginatus Say; (57) P. interruptus Say; (58) P. navus Cr.; (59) Priocnemis agenioides Fox; (60) P. fulvicornis Cr.; (61) Ceropales elegans Cr.; (62) C. bipunctata Say; (63) C. fulvipes Cr.; *Scoliidae:* (64) Myzine 6-cincta F.; (65) Scolia nobilitata F.; (66) S. bicincta F.; *Chalcididae:* (67) Perilampus platygaster Say; (68) P. fulvicornis Ashm.; *Braconidae:* (69) Iphiaulax rugator Say, ab.; (70) Bracon simplex Cr.; (71) B. vernoniae Ashm.; (72) Chelonus sericeus Say, (73) Apanteles sp.; (74) Agathis sp.; (75) A. areolata Ashm., freq.; *Ichneumonidae:* (76) Limneria eurycreontis Ashm.; (77) Cremastus retiniae Cr.; (78) Lampronota americana Cr.; (79) L. varia Cr.

Diptera—*Bombylidae:* (80) Exoprosopa fascipennis Say; (81) Sparnopolius fulvus Wd.; (82) Geron senilis F.; (83) Toxophora amphitea Wlk.; *Conopidae:* (84) Physocephala texana Will.; (85) Zodion fulvifrons Say; (86) Oncomyia loraria Lw.; *Syrphidae:* (87) Paragus bicolor F.; (88) Chrysogaster nitida Wd., f. p.; (89) Chilosia sp.; (90) Platychirus hyperboreus Staeg. (?); (91) P. quadratus Say; (92) Xanthogramma divisa Will.; (93) Allograpta obliqua Say; (94) Mesograpta geminata Say; (95) Eristalis tenax L.; (96) E. dimidiatus Wd., ab.; (97) E. latifrons Lw.; (98) E. bastardi Mcq.; (99) Helophilus similis Mcq., ab.; (100) H. latifrons Lw.; (101) Tropidia mamillata Lw., freq.; (102) Syritta pipiens L.; (103) Spilomyia longicornis Lw.; (104) S. quadrifasciata Say; *Tachinidae:* (105) Cistogaster occidua Wlk.; (106) Gymnosoma fuliginosa R. D.; (107) Ennyomma clistoides Twns.; (108) Phasioclista metallica Twns.; (109) Loewia nigrifrons Twns.; (110) Trixoclista distincta Twns.; (111) Euryceromyia robertsonii Twns.; *Sarcophagidae:* (112–114) Sarcophaga spp.; *Muscidae:* (115) Graphomyia sp.; (116) Lucilia cornicina F., s. and f. p., ab.; (117) Compsomyia macellaria F., f. p., freq.; (118) Stomoxys calcitrans L., s.; *Anthomyidae:* (119) Anthomyia albicincta Fll.; (120) Chortophila sp.; *Trypetidae:* (121) Trypeta humilis Lw.

Coleoptera — *Carabidae:* (122) Callida punctata Lec.; *Coccinellidae:* (123) Megilla maculata DeG., f. p.; (124) Hippodamea glacialis F., freq.; (125) Coccinella 9-notata Hbst.; *Lampyridae:* (126) Chauliognathus pennsylvanicus DeG., f. p., ab.; *Malachidae:* (127) Collops 4-maculatus F.; *Scarabaeidae:* (128) Euphoria sepulchralis F., f. p., ab.; *Cerambycidae:* (129) Cyllene robiniae Forst., f. p., freq.; (130) C. decorus Oliv., f. p.; *Chrysomelidae:* (131) Diabrotica 12-punctata Oliv., f. p., ab.; (132) D. vittata F., f. p.; (133) D. longicornis Say, f. p., ab.; *Bruchidae:* (134) Bruchus obsoletus Say; *Meloidae:* (135) Epicauta pennsylvanica De G., f. p., ab.

Lepidoptera — *Rhopalocera:* (136) Danais archippus F.; (137) Pyrameis cardui L.; (138) Chrysophanus thoe B. — L.; (139) Colias philodice Gdt.; *Heterocera:* (140) Scepsis fulvicollis Hbn.; (141) Feltia subgothica Steph.; (142) Carneades velleripennis Grt.; (143) Heliothis armiger Hbn., ab.

Hemiptera — *Coreidae:* (144) Alydus pilosulus Schf., s.; *Lygaeidae:* (145) Lygaeus turcicus F., s.; *Capsidae:* (146) Calocoris rapidus Say, s.

SOLIDAGO NEMORALIS Ait. — Visitors observed September 26 and October 5 and 9 :—

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s.; (2) Bombus virginicus Oliv. ☿, s.; (3) B. americanorum F. ♂♀☿, s.; (4) Ceratina dupla Say ♂♀, s., freq.; (5) Megachile brevis Say ♀, s.; (6) Epeolus mercatus F. ♀, s.; (7) Calliopsis compositarum Rob. ♀, s.; (8) C. asteris Rob. (MS) ♀, s. and c. p.; *Andrenidae:* (9) Andrena nubecula Sm. ♀, s. and c. p., freq.; (10) Halictus sp. ♀, s.; (11) H. pectoralis Sm. ♀, s.; (12) H. ligatus Say ♂, s.; (13) H. cressonii Rob. ♂, s.; (14) H. confusus Sm. ♂♀, s. and c. p., freq.; (15) Augochlora similis Rob. ♀, s.; (16) Colletes compacta Cr. ♀, s. and c. p.; (17) C. americana Cr. ♂♀, s. and c. p., ab.; (18) C. eulophi Rob. ♀, s. and c. p.; (19) Prosopis pygmaea Cr. ♀, s., freq.; *Vespidae:* (20) Polistes rubiginosus Lep.; (21) P. pallipes Lep., freq.; (22) P. metricus Say, freq.; (23) P. annularis L.; *Eumenidae:* (24) Odynerus sp.; (25) O. tigris Sauss.; (26) O. foraminatus Sauss.; (27) O. anormis Say; *Crabronidae:* (28) Crabro interruptus Lep., freq.; (29) C. rufifemur Pk.; *Mimesidae:* (30) Mimesa denticulata Pk.; *Philanthidae:* (31) Philanthus punctatus Say; (32) Cerceris clypeata Dahlb.; (33) C. finitima Cr.; (34) C. kennicottii Cr.; *Larridae:* (35) Ancistromma distincta Sm.; *Sphecidae:* (36) Ammophila gryphus Sm.; (37) A. vulgaris Cr.; (38) A. pictipennis Walsh; *Pompilidae:* (39) Pompilus sp.; (40) P. marginatus Say; (41) Ceropales fulvipes Cr.; *Chrysididae:* (42) Chrysis perpulchra Cr.; *Braconidae:* (43) Chelonus sericeus Say — all s.

Diptera — *Bombylidae:* (44) Systropus macer F., s.; *Syrphidae:* (45) Syrphus americanus Wd.; (46) S. arcuatus Fll.; (47) Sphaerophoria cylindrica Say; (48) Spilomyia longicornis Lw.; (49) Syritta pipiens L. — all s. or f. p.; *Tachinidae:* (50) sp.; (51) Gymnosoma fuliginosa R. D.; (52) Jurinia smaragdina Mcq.; (53) Sarcomacronychia aurifrons Twns., freq.; *Sarcophagidae:* (54 and 55) spp.; *Muscidae:* (56) sp.; (57) Stomoxys calcitrans L.; (58) Lucilia sp.; (59) L. cornicina F.; (60) L. latifrons Schin.; (61) Compsomyia macellaria F.; *Trypetidae:* (62) Trypeta solaris Lw.; (63) T. humilis Lw.; *Oscinidae:* (64) Chlorops sp. — all s.

Lepidoptera — *Rhopalocera:* (65) Danais archippus F.; (66) Colias philodice Gdt.; (67) Terias lisa B. — L.; *Heterocera:* (68) Scepsis fulvicollis Hbn.; (69) Utetheisa bella L.; (70) Heliothis armiger Hbn. — all s.

Coleoptera — *Coccinellidae:* (71) Coccinella 9-notata Hbst.; *Lampyridae:* (72) Chauliognathus pennsylvanicus DeG.; *Cerambycidae:* (73) Cyllene robiniae Forst.; *Meloidae:* (74) Epicauta pennsylvanica DeG., ab., in cop. — all f. p.

Hemiptera — *Coreidae:* (75) Alydus pilosulus Schf.; *Capsidae:* (76) Lygus pratensis L.— both s.

SOLIDAGO LANCEOLATA L.— Visitors — September 6, 8, 9, 12, 13, and 25:—

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s. and c. p., ab.; (2) Bombus virginicus Oliv. ☿, c. p., freq.; (3) B. americanorum F. ♂☿, s., freq.; (4) B. scutellaris Cr. ☿, s.; (5) B. separatus Cr. ♂, s.; (6) Melis-

sodes perplexa Cr. ♀, c. p., freq.; *Andrenidae:* (7) Andrena solidaginis Rob. ♀, s.; (8) Halictus ligatus Say ♀, s. and c. p.; (9) H. confusus Sm. ♀, c. p.; (10) Colletes spinosa Rob. ♀, c. p.; *Vespidae:* (11) Polistes metricus Say; (12) P. pallipes Lep.; *Eumenidae:* (13) Odynerus tigris Sauss.; (14) O. capra Sauss., ab.; (15) O. catskillensis Sauss.; *Crabronidae:* (16) Crabro 10-maculatus Say; *Philanthidae:* (17) Eucerceris zonatus Say; *Bembecidae:* (18) Megastizus brevipennis Walsh; (19) Bembex nubillipennis Cr.; *Larridae:* (20) Ancistromma distincta Sm.; *Sphecidae:* (21) Priononyx atrata Lep.; *Pompilidae:* (22) Priocnemis fulvicornis Cr.; *Scoliidae:* (23) Myzine sexcincta F.; (24) Scolia bicincta F.;— all s.

Diptera — *Syrphidae:* (25) Sphaerophoria cylindrica Say; (26) Helophilus similis Mcq., ab.; (27) H. latifrons Lw.; *Tachinidae:* (28) Cistogaster occidua Wlk.; (29) Miltogramma flavicornis Twns.; (30) Atrophopoda singularis Twns.; *Muscidae:* (31) Lucilia cornicina F.; (32) Compsomyia macellaria F.— all s. or f. p.

Lepidoptera — *Rhopalocera:* (33) Phyciodes tharos Dru.; (34) Pyrameis huntera F.; (35) Chrysophanus thoe B. — L.; (36) Lycaena comyntas Gdt.; (37) Colias philodice Gdt.; *Heterocera:* (38) Utetheisa bella L.; (39) Heliothis armiger Hbn.; (40) Crambus laqueatellus Clem. — all s.

Coleoptera — *Lampyridae:* (41) Chauliognathus pennsylvanicus De G., f. p., ab.; *Meloidae:* (42) Epicauta pennsylvanica De G., f. p., ab.

Boltonia asteroides L'Her.— The plants are often collected in rather large patches in moist places, and are quite attractive to insects. The heads have yellow disc florets and white rays, and expand fifteen millimetres or more. The rays are pistillate, the disc florets being perfect. Nectar and pollen are supplied by the latter. The tubes of the disc florets are only about one millimetre deep, so that numerous short-tongued insects can obtain the nectar.

The list of visitors was observed September 20, 28, October 2 and 4:—

Hymenoptera — *Apidae:* (1) Bombus americanorum F. ☿, s.; (2) Melissodes sp. ♀, s.; (3) M. confusa Cr. ♀, s. and c. p.; (4) Megachile mendica Cr. ♀, s.; (5) M. brevis Say ♀, s.; (6) Calliopsis compositarum Rob. ♂♀, s. and c. p., ab.; (7) C. solidaginis Rob. ♀, s.; *Andrenidae:* (8) Andrena solidaginis Rob. ♂♀, s. and c. p.; (9) Halictus ligatus Say ♂♀, s.; (10) H. confusus Sm. ♂♀, s. and c. p., freq.; (11) Agapostemon radiatus Say ♀, s.; (12) Sphecodes mandibularis Cr. ♀, s.; (13) Colletes americana Cr. ♂♀, s. and c. p., ab.; (14) Prosopis affinis Sm. ♂, s.; (15) P. pygmaea Cr. ♂♀, s.; *Vespidae:* (16) Polistes pallipes Lep., s.; *Eumenidae:* (17) Odynerus anormis Say, s.; *Sphecidae:* (18) Priononyx thomae F., s.

Diptera — *Bombylidae:* (19) Sparnopolius fulvus Wd., s.; *Conopidae:* (20) Oncomyia loraria Lw., s.; *Syrphidae:* (21) Paragus tibialis Fll.; (22) Syrphus americanus Wd.; (23) Mesograpta marginata Say; (24) Sphaerophoria cylindrica Say; (25) Eristalis dimidiatus Wd.; (26) Syritta pipiens L.—

all s. or f. p.; *Tachinidae:* (27) sp.; (28) Hyalomyia purpurascens Twns., freq.; (29) Gymnosoma fuliginosa R. D.; (30) Cistogaster occidua Wlk.; (31) C. immaculata Mcq.; (32) Miltogramma cinerascens Twns., freq.; (33) M. flavicornis Twns.; (34) M. argentifrons Twns.; (35) Sarcomacronychia aurifrons Twns.; (36) Acroglossa hesperidarum Will., freq.; (37) Leucostoma atra Twns.; *Sarcophagidae:* (38) sp.; (39) Sarcophaga sp.; *Muscidae:* (40) Compsomyia macellaria F.; *Anthomyidae:* (41) sp.; (42) Anthomyia sp.; *Trypetidae:* (43) Trypeta humilis Lw., ab.; *Sepsidae:* (44) Sepsis sp.—all s.

Lepidoptera — *Rhopalocera:* (45) Phyciodes tharos Dru.; (46) Colias philodice Gdt.; (47) Pamphila phylaeus Dru.; *Heterocera:* (48) Scepsis fulvicollis Hbn.; (49) Utetheisa bella L.; (50) Heliothis armiger Hbn.—all s.

Coleoptera — *Coccinellidae:* (51) Hippodamea parenthesis Say; *Lampyridae:* (52) Chauliognathus pennsylvanicus DeG.; *Chrysomelidae;* (53) Diabrotica longicornis Say, freq.; (54) D. 12-punctata Oliv., freq. — all f. p.

Hemiptera — *Capsidae:* (55) Lygus pratensis L., s.

Aster novae-angliae L. — The plants often grow in rather large patches and bear numerous showy heads with yellow discs and violet purple rays. The heads expand two and three centimetres. Nectar and pollen are supplied by the disc florets. The tubes of these measure three or four millimetres in length.

The visitors observed October 2, 4, 7, 8 and 10 are as follows :—

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s. and c. p.; (2) Bombus americanorum F. ♂ ♀ ☿, s. and c. p., freq.; (3) B. virginicus Oliv. ♂, s.; (4) B. separatus Cr. ♂, s.; (5) Melissodes desponsa Sm. ♀, s. and c. p.; (6) M. confusa Cr. ♀, s. and c. p.; (7) M. perplexa Cr. ♀, s. and c. p.; (8) M. aurigenia Cr. ♀, s. and c. p.; (9) Ceratina dupla Say ♀, s. and c. p.; (10) Megachile latimanus Say ♀, s. and c. p., freq.; (11) M. brevis Say ♀, s. and c. p., freq.; (12) Calliopsis compositarum Rob. ♀, c. p.; *Andrenidae:* (13) Andrena solidaginis Rob. ♀, c. p.; (14) A. helianthi Rob. ♀, c. p.; (15) Halictus parallelus Say ♂, s.; (16) H. ligatus Say ♂, s.; (17) Colletes americana Cr. ♀, c. p.

Lepidoptera — *Rhopalocera:* (18) Danais archippus F.; (19) Phyciodes tharos Dru.; (20) Pyrameis cardui L.; (21) Pieris protodice B.— L. (22) Colias philodice Gdt., ab.; (23) Meganostoma caesonia Stoll; (24) Pamphila peckius Kby.; (25) P. phylaeus Dru.; *Heterocera:* (26) Plusia simplex Gn.; (27) Heliothis armiger Hbn.— all s.

Diptera—*Conopidae:* (28) Stylogaster biannulata Say, s., freq.; *Syrphidae:* (29) Syrphus americanus Wd., f. p.; (30) Eristalis dimidiatus Wd., s.; (31) E. latifrons Lw., s.; (32) E. tenax L., s. and f. p.; (33) E. transversus Wd., s.; (34) Helophilus similis Mcq., s.; (35) Tropidia mamillata Lw., f. p.

ASTER PANICULATUS Lam.—Visitors—October 8, 9, 11, 17:—

Hymenoptera—*Apidae:* (1) Apis mellifica L. ☿, s., ab.; (2) Bombus virginicus Oliv. ♂, s., freq.; (3) B. americanorum F. ☿, s.; (4) Melissodes confusa Cr. ♀, s. and c. p.; (5) M. perplexa Cr. ♀, s. and c. p.; (6) Ceratina dupla Say ♀, s.; (7) Megachile latimanus Say ♀, s.; (8) M. brevis Say ♂♀, s. and c. p.; (9) Coelioxys altilis Cr. ♀, s.; (10) Heriades carinatum Cr. ♀, s.; (11) Calliopsis compositarum Rob. ♀, s. and c. p.; *Andrenidae:* (12) Andrena solidaginis Rob. ♀, s.; (13) A. asteris Rob. ♀♂, s.; (14) A. nubecula Sm. ♀, s.; (15) Agapostemon radiatus Say ♂, s.; (16) Augochlora similis Rob. ♀, s.; (17) Halictus pectoralis Sm. ♀, s.; (18) H. coriaceus Sm. ♂, s.; (19) H. forbesii Rob. ♂, s.; (20) H. lerouxii Lep. ♀, s.; (21) H. ligatus Say ♂♀, s., ab.; (22) H. fasciatus Nyl. ♀, s.; (23) H. zephyrus Sm. ♀, s.; (24) H. confusus Sm. ♂♀, s. and c. p.; (25) H. stultus Cr. ♀. s. and c. p., ab.; (26) Sphecodes dichroa Sm. ♂, s.; (27) Colletes compacta Cr. ♀, s.; (28) C. americana Cr. ♀, s.; (29) Prosopis pygmaea Cr. ♀, s.; *Vespidae:* (30) Vespa maculata L.; (31) V. germanica F.; (32) Polistes rubiginosus Lep., ab.; (33) P. metricus Say; (34) P. pallipes Lep.; *Eumenidae:* (35) Eumenes fraternus Say; (36) Odynerus tigris Sauss.; (37) O. capra Sauss.; (38) O. catskillensis Sauss.; (39) O. arvensis Sauss.; (40) O. foraminatus Sauss.; (41) O. anormis Say; (42) O. sp.; *Philanthidae:* (43) Philanthus politus Say; (44) P. punctatus Say; (45) Eucerceris zonatus Say; (46) Cerceris clypeata Dlb.; *Larridae:* (47) Notogonia argentata Bv.; *Sphecidae:* (48) Ammophila gryphus Sm.; (49) A. vulgaris Cr.; (50) A. intercepta Lep.; (51) A. gracilis Lep.; (52) Isodontia philadelphica Lep.; *Pompilidae:* (53) Pompilus biguttatus F.; *Scoliidae:* (54) Myzine sexcincta F.; *Chalcididae:* (55) Torymus sp.; *Braconidae:* (56) Bracon longicaudus Prov.; *Ichneumonidae:* (57) Lampronota varia Cr. — all s.

Diptera — *Conopidae:* (58) Oncomyia loraria Lw.; *Syrphidae:* (59) Syrphus americanus Wd.; (60) S. ribesii L.; (61) Mesograpta marginata Say; (62) M. geminata Say; (63) Sphaerophoria cylindrica Say; (64) Eristalis tenax L.; (65) E. aeneus F.; (66) E. dimidiatus Wd.; (67) E. transversus Wd.; (68) Syritta pipiens L.; (69) Spilomyia quadrifasciata Say; *Tachinidae:* (70) Hyalomyia robertsonii Twns.; (71) Trichopoda pennipes F.; (72) Jurinia smaragdina Mcq.; (73) Micropalpus fulgens Mg.; (74) Acroglossa hesperidarum Will.; (75) Miltogramma cinerascens Twns.; *Sarcophagidae:* (76) Sarcophaga sp.; *Muscidae:* (77) Stomoxys calcitrans L.; (78) Graphomyia sp.; (79 and 80) Lucilia spp.; (81) L. caesar L.; (82) L. latifrons Schin.; (83) L. cornicina F.; (84) Compsomyia macellaria F. — all s. or f. p.

Lepidoptera — *Rhopalocera:* (85) Phyciodes tharos Dru.; (86) Pyrameis cardui L.; (87) P. huntera F.; (88) Lycaena pseudargiolus B. — L.; (89) Pieris rapae L.; (90) P. protodice B. — L.; (91) Colias philodice Gdt.; (92) Pamphila peckius Kby.; (93) P. campestris Bdv., var. huron Edw.; (94) Nisoniades martialis Scud.; *Heterocera:* (95) Scepsis fulvicollis Hbn.; (96) Plusia simplex Gn. — all s.

Coleoptera — *Lampyridae:* (97) Chauliognathus pennsylvanicus De G.; *Scarabaeidae:* (98) Euphoria sepulchralis F.; *Cerambycidae:* (99) Cyllene robiniae Forst.

Hemiptera — *Coreidae:* (100) Alydus eurinus Say, s.

ERIGERON PHILADELPHICUS L. — The stems grow a few decimetres high and expose several heads which expand about two centimetres. The ray florets are pistillate, are very numerous and slender and white, or purplish tinted. The disc florets are yellow. The tubes are very narrow and measure about four millimetres in length. The nectar is easily obtained by small, long-tongued insects which find a convenient resting-place upon the disc. Pollen is forced out of the anther tube in the usual way.

The flower blooms from April 26 to June 13. On May 24 and 28 and June 2 and 5, the following list was observed: —

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s., one; (2) Ceratina tejonensis Cr. ♂, s., freq.; (3) C. dupla Say ♂♀, s. and c. p., ab.; (4) Alcidamea producta Cr. ♂, s.; (5) Heriades carinatum Cr. ♂, s.; (6) Stelis lateralis Cr. ♂♀, s., freq.; (7) Nomada annulata Sm. ♂♀, s., ab.; *Andrenidae:* (8) Halictus pectoralis Sm. ♀, s.; (9) H. coriaceus Sm. ♀, s. and c. p.; (10) H. ligatus Say ♀, s. and c. p., ab.; (11) H. fasciatus Nyl. ♀, s. and c. p., freq.; (12) H. pilosus Sm. ♀, s. and c. p.; (13) H. confusus Sm. ♀, s. and c. p., freq.; (14) H. albipennis Rob. ♀, s.; (15) Augochlora pura Say ♀, s.; (16) A. similis Rob. ♀, s. and c. p.; (17) Sphecodes mandibularis Cr. ♀, s.; (18) Prosopis pygmaea Cr. ♂, s.; *Eumenidae:* (19 and 20) Odynerus spp., freq.; (21) O. foraminatus Sauss.; (22) O. anormis Say, ab.; *Sphecidae:* (23) Ammophila vulgaris Cr. — all s.

Diptera — *Conopidae:* (24) Zodion fulvifrons Say, s., freq.; (25) Oncomyia loraria Lw., s.; *Syrphidae:* (26) Paragus bicolor F.; (27) P. tibialis Fll.; (28) Mesograpta marginata Say; (29) Sphaerophoria cylindrica Say; *Tachinidae:* (30) sp.; (31) Hyalomyia purpurascens Twns.; (32) Cistogaster occidua Wlk., ab.; (33) C. immaculata Mcq.; (34) Siphophyto sp.; (35) Leucostoma atra Twns.; *Sarcophagidae:* (36–38) Sarcophaga spp.; *Muscidae:* (39) Lucilia cornicina F.; *Anthomyidae:* (40) Anthomyia albicincta Fll.; (41) Chortophila sp. — all s. or f. p.

Coleoptera — *Lampyridae:* (42) Telephorus flavipes Lec.; *Scarabaeidae:* (43) Trichius piger F., ab.; *Chrysomelidae:* (44) Diabrotica 12-punctata Oliv. all f. p.

Lepidoptera — *Rhopalocera:* (45) Phyciodes tharos Dru.; (46) Chrysophanus thoe B.—L.; (47) Ancyloxypha numitor F.; (48) Pamphila peckius Kby.; (49) P. cernes B.—L.; *Heterocera:* (50) Scepsis fulvicollis Hbn.— all s.

Hemiptera — *Capsidae:* (51) Calocoris rapidus Say; (52) Lygus pratensis L.; *Berytidae:* (53) Corizus lateralis Say — all s.

ERIGERON STRIGOSUS Muhl.—This plant resembles *E. philadelphicus*, but is taller, blossoms later, and has white rays which are less numerous and broader. The corolla tubes are shorter, about two millimetres in length.

The insect visitors, as might be expected, closely resemble those of the species just mentioned.

I have noted this plant in bloom from May 17 to September 15. On May 31 and June 8, 12 and 14, I observed the following visitors:—

Hymenoptera—*Apidae:* (1) Apis mellifica L. ☿, s.; (2) Ceratina tejonensis Cr. ♂, s.; (3) C. dupla Say ♂♀, s. and c. p., freq.; (4) Heriades carinatum Cr. ♂♀, s.; (5) Nomada annulata Cr. ♀, s.; *Andrenidae:* (6) Halictus pectoralis Sm. ♀, s. and c. p.; (7) H. ligatus Say ♀, s. and c. p., freq.; (8) H. fasciatus Nyl. ♀, s. and c. p., freq.; (9) H. confusus Sm. ♀, s. and c. p., freq.; (10) H. albipennis Rob. ♀, s. and c. p., freq.; (11) H. pruinosus Rob. ♀, s. and c. p.; (12) H. tegularis Rob. ♀, s. and c. p.; (13) Augochlora similis Rob. ♀, s. and c. p.; (14) Prosopis affinis Sm. ♀, s.; (15) P. pygmaea Cr. ♀, s.; *Eumenidae:* (16-18) Odynerus spp., s., freq.; (19) O. anormis Say, s., freq.; *Philanthidae:* (20) Cerceris clypeata Dahlb., s.; *Sphecidae:* (21) Ammophila pictipennis Walsh, s.; *Chrysididae:* (22) Chrysis sp., s.; *Chalcididae:* (23) Leucospis affinis Say, s.; *Braconidae:* (24) Bracon longicaudus Prov., s.

Diptera—*Empidae:* (25) Empis sp., s.; *Conopidae:* (26) Zodion fulvifrons Say, s.; *Syrphidae:* (27) Paragus bicolor F.; (28) P. tibialis Fll.; (29) Mesograpta geminata Say; (30) M. marginata Say, freq.; (31) Sphaerophoria cylindrica Say; (32) Eristalis dimidiatus Wd.; (33) Tropidia mamillata Lw.; (34) Syritta pipiens L.; *Tachinidae:* (35) sp. (36) Hyalomyia purpurascens Twns.; (37) Gymnosoma fuliginosa R. D.; (38) Cistogaster occidua Wlk.; (39) C. immaculata Mcq.; (40) Ocyptera euchenor Wlk.; (41) Miltogramma cinerascens Twns.; (42) M. argentifrons Twns.; (43) M. flavicornis Twns., freq.; (44) Sarcomacronychia aurifrons Twns.; (45) Leucostoma atra Twns.; *Sarcophagidae:* (46 and 47) Sarcophaga spp.; *Muscidae:* (48) Lucilia cornicina F.; *Anthomyidae:* (49) Anthomyia albicincta Fll.; (50) Limnophora sp.; (51) Chortophila sp.; *Muscidae acalyptratae:* (52) sp.—all s. or f. p.

Coleoptera—*Malachidae:* (53) Collops 4-maculatus F.; *Mordellidae:* (54) Mordellistena comata Lec., freq.—both f. p.

Lepidoptera—*Lycaenidae:* (55) Chrysophanus thoe B.—L., s.

Hemiptera—*Capsidae:* (56) Lygus pratensis L., s.

ANTENNARIA PLANTAGINIFOLIA Hook.—This is the earliest of the indigenous Compositae, blooming from April 12 to May 6. On ten days—April 14 to May 4—the following visitors were observed:—

Hymenoptera—*Apidae:* (1) Bombus americanorum F. ♀, s., one; (2) Ceratina tejonensis Cr. ♂.; (3) C. dupla Say ♂, s., ab.; (4) Nomada maculata Cr. ♂; (5) N. luteola Lep. ♀; *Andrenidae:* (6) Panurgus? andrenoides Cr. ♀, s.; (7) Andrena sayi Rob. ♀, s.; (8) A. claytoniae Rob. ♂, s. (9) Augochlora pura Say ♀, s. and c. p., freq.; (10) A. similis Rob. ♀, s. and c. p.; (11) Halictus lerouxii Lep. ♀, s.; (12) H. ligatus Say ♀, s. and c. p.

ab.; (13) H. fasciatus Nyl. ♀, s. and c. p., ab.; (14) H. confusus Sm. ♀, s. and c. p., ab.; (15) H. stultus Cr. ♀, s. and c. p., ab.; (16) Sphecodes antennariae Rob. ♀, s.

Diptera — *Empidae:* (17) Empis sp., s.; *Syrphidae:* (18) Chrysogaster nitida Wd.; (19) Platychirus quadratus Say; (20) P. hyperboreus Staeg.; (21) Mesograpta geminata Say; (22) M. marginata Say; (23) Sphaerophoria cylindrica Say; (24) Eristalis aeneus F.— all s. and f. p.; *Tachinidae:* (25) Gonia frontosa Say, s., ab.; (26) Phorocera edwardsii Will.; *Sarcophagidae:* (27) Sarcophaga sp.; (28) Cynomyia sp.; *Muscidae:* (29) Cyrtoneura sp.; (30) Lucilia cornicina F.; *Anthomyidae:* (31) Limnophora sp.; (32 and 33) Chortophila spp. *Oscinidae:* (34) Chlorops sp.— all s. or f. p.

Lepidoptera — *Rhopalocera:* (35) Pyrameis huntera F.; (36) Nisoniades brizo B.— L.; *Heterocera:* (37) Drasteria erechtea Cram.

Coleoptera — *Oedemeridae:* (38) Asclera ruficollis Say, f. p.

Silphium integrifolium Michx.— The plant is common on prairies, grows from one to two metres high, and bears yellow heads which expand about four or five centimetres.

The ray-flowers are female; those of the disc, male. The disc-flowers have a long, undivided hairy style which serves to expose the pollen to the visitors. Nectar is secreted by the disc flowers, which have tubes six or seven millimetres long. This places the nectar beyond the reach of short-tongued insects.

The flowers bloom from July 9 to September 7. The visitors were observed on July 13, 14, 19, 28, and August 9: —

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s., one; (2) Melissodes dentiventris Sm. ♂, s., freq.; (3) M. aurigenia Cr. ♂, s., freq.; (4) M. obliqua Say ♂, s.; (5) Ceratina dupla Say ♀, s., freq.; (6) Megachile pugnata Say ♂♀, s. and c. p., ab.; (7) M. inimica Cr. ♂, s.; (= M. sayi Cr.); (8) M. montivaga Cr. ♂, s.; (9) M. petulans Cr. ♂, s., freq.; (10) M. brevis Say ♂, s.; (11) Epeolus remigatus F. ♂, s.; (12) E. lunatus Say ♂, s.; *Andrenidae:* (13) Halictus ligatus Say ♀, s.; (14) Agapostemon viridula F. ♂♀, s. and c. p.

Diptera — *Bombylidae:* (15) Systoechus vulgaris Lw., s.; *Tachinidae:* (16) Cistogaster occidua Wlk., s.

Silphium laciniatum L.— Visitors — July 16, 18, 20, 25, and August 4:—

Hymenoptera — *Apidae*: (1) Apis mellifica L. ☿, s.; (2) Bombus separatus Cr. ☿♀, s., (3) B. americanorum F. ☿, s.; (4) Melissodes aurigenia Cr. ♂♀, s., ab.; (5) M. coloradensis Cr. ♂, s.; (6) M. bimaculata Lep. ♂, s.; (7) Ceratina dupla Say ♀, s.; (8) Megachile brevis Say ♀, s.; (9) M. pugnata Say ♀, s. and c. p.; (10) Epeolus remigatus F. ♂, s.; *Andrenidae*:

(11) Agapostemon texanus Cr. ♀, s.; (12) A. viridula F. ♀, s. and c. p.; (13) Halictus ligatus Say ♀, c. p.; (14) H. pilosus Sm. ♀, c. p.; (15) H. stultus Cr. ♀, c. p.

Diptera — *Conopidae:* (16) Zodion leucostoma Will.; (17) Z. fulvifrons Say; *Syrphidae:* (18) Allograpta obliqua Say; (19) Eristalis latifrons Lw.: (20) E. transversus Wd.— all s.

Lepidoptera — *Rhopalocera:* (21) Danais archippus F.; (22) Colias philodice Gdt., freq. — both s.

Parthenium integrifolium L.— The stems grow from seven to ten decimetres high, and bear dense flat-topped corymbs of heads which measure about eight millimetres across.

Each head contains five fertile flowers with broad and short obcordate ligules. Each fertile flower thus has a cup-like form. The disc flowers are numerous and sterile. The pistillate flowers are white. The lobes of the staminate flowers and the chaff are terminated by white club-shaped hairs which make the heads looks somewhat woolly and very white.

The flat corymbs form a very conspicuous and convenient landing place. The shallow ray-flowers furnish nectar, and the disc-flowers afford abundant pollen. Numerous small and short-tongued visitors are the result.

I have found the Parthenium in bloom from June 6 to July 30. On the 21st and 27th of June and the 11th of July I noted as visitors:—

Hymenoptera — *Apidae* (1) Ceratina dupla Say ♀, s. and c. p.; (2) Megachile montivaga Cr. ♀, c. p.; (3) Heriades carinatum Cr. ♂♀, s. and c. p.; *Andrenidae:* (4) Halictus ligatus Say ♀, s.; (5) H. fasciatus Nyl. ♀, s. and c. p.; (6) H. pilosus Sm. ♀, s. and c. p.; (7) H. confusus Sm. ♂♀, s. and c. p., ab.; (8) Augochlora similis Rob. ♀, s. and c. p., freq.; (9) A humeralis Pttn. ♀, s.; (10) Prosopis pygmaea Cr. ♂, s.; *Eumenidae:* (11–13) Odynerus spp., freq.; (14) O. anormis Say; *Crabronidae:* (15) Crabro interruptus Lep.; (16) Oxybelus frontalis Rob., freq.; (17) O. emarginatus Say; *Philanthidae:* (18) Cerceris robertsonii Fox; (19) C. compacta Cr.; *Sphecidae:* (20) Ammophila intercepta Lep.; *Scoliidae:* (21) Myzine sexcincta F.; *Chrysididae:* (22) Hedychrum violaceum Brullé v. parvum Aaron; *Braconidae:* (23) Bracon sp.; (24) Agathis vulgaris Cr.; *Tenthredinidae:* (25) Hylotoma humeralis Bv. — all s.

Diptera — *Empidae* (26) Empis sp., s.; *Conopidae:* (27) Zodion fulvifrons Say, s.; *Syrphidae:* (28) Mesograpta marginata Say; (29) M. geminata Say, (30) Sphaerophoria cylindrica Say; (31) Syritta pipiens L.; *Tachinidae:* (32) sp.; (33) Hyalomyia purpurascens Twns.; (34) Cistogaster occidua Wlk.; (35) Ocyptera euchenor Wlk.; (36) Miltogramma cinerascens Twns., freq.; (37) M. argentifrons Twns.; (38) M. flavicornis Twns.;

Sarcophagidae: (39) sp.; (40 and 41) Sarcophaga spp.; *Muscidae:* (42) Stomoxys calcitrans L.; (43) Lucilia cornicina F.; (44) L. sylvarum Mg.; *Anthomyidae:* (45) Anthomyia sp.; (46) A. albicincta Fll.; *Muscidae acalyptratae:* (47) sp.—all s. or f. p.

Coleoptera—*Scarabaeidae:* (48) Trichius piger F., s. and f. p., freq.; *Cerambycidae:* (49) Typocerus sinuatus Newm., f. p., freq.; *Chrysomelidae:* (50) Diabrotica 12-punctata Oliv., f. p.; (51) D. atripennis Say, s.; *Mordellidae:* (52) Pentaria trifasciata Melsh., s.; *Rhipiphoridae:* (53) Rhipiphorus limbatus F., s.

Hemiptera—*Capsidae:* (54) Lygus pratensis L., freq.; (55) Calocorus rapidus Say; *Corimelaenidae:* (56) Corimelaena pulicaria Germ.—all s.

ECHINACEA ANGUSTIFOLIA * DC.—This purple Cone-flower is one of the handsomest of native plants. It grows on prairies. The stems grow from five to ten decimetres high and bear large conical heads with long drooping rays, which are rose-red. The rays are sterile, the disc flowers being hermaphrodite. The corollas measure five millimetres in length, their rigid lobes being erect and rather closely approximated. The nectar is, therefore, deeply seated and closely concealed. The pollen is carried upwards and exposed on the hairy styles. In most of the Compositae the pollen may be gathered with great facility by bees which run about over the heads. In *Echinacea*, however, each pair of pollen-laden styles is guarded by the stiff tip of a bract, so that it is fairly impossible for any except the smallest bees to collect the pollen, and these cannot do it easily. I have seen the female of *Melissodes obliqua* trying in vain to collect pollen of *E. purpurea*.

The stiff bracts also serve to render the nectar less accessible. On account of the deep-seated nectar, the narrow passage to it, the stiff bracts, excluding bees, and the bright color I am inclined to regard the flowers of *Echinacea* as specially adapted to butterflies, and these, as far as I have observed, are the principal guests.

Echinacea angustifolia, as far as observed, blooms from June 3rd to 30th. June 14, 20 and 21 I noted as visitors:—

Lepidoptera—*Rhopalocera:* (1) Danais archippus F.; (2) Chrysophanus

* The plant is figured in Goodale and Sprague "Wild Flowers of America," Plate XXV.

thoe B.—L.; (3) Colias philodice Gdt.; (4) Pamphila peckius Kby.; (5) P. cernes B.—L.—all s.

Hymenoptera — *Apidae:* (6) Ceratina dupla Say ♀, s. and c. p.; (7) Megachile montivaga Cr. ♂, s.; *Andrenidae:* (8) Agapostemon viridula F. ♀.

Coleoptera — *Cerambycidae:* (9) Typocerus sinuatus Newm., f. p.

ECHINACEA PURPUREA Moench.— The stems are taller and more branched than in *E. angustifolia* and, accordingly, the heads are more numerous. The rays are rose-purple, and more expanded than in *E. angustifolia.* The discs appear yellow from the color of the tips of the bracts. The tubes of the disc-florets are narrow and measure about five millimetres long. The rigid tips of the chaff surpass the corollas for three or four millimetres and are so closely crowded that insects cannot reach the nectar unless they are provided with a proboscis eight or nine millimetres long. Pollen is carried out on the hairy tips of the styles but is so closely guarded by the chaff-tips that pollen-collecting bees are unable to remove it.

As in the case of the preceding, the flower seems to be adapted to butterflies, which are the principal visitors.

The plant blooms from June 18 to September 14. August 8 and 24, and September 14 the following visitors were noted: —

Lepidoptera — *Rhopalocera:* (1) Danias archippus F.; (2) Phyciodes nycteis D.—H.; (3) Pieris rapae L.; (4) Colias philodice Gdt.; (5) Papilio troilus L.—all s.

Hymenoptera — *Apidae:* (6) Apis mellifica L. ☿, s., one; (7) Bombus separatus Cr. ♂, s.; (8) Melissodes obliqua Say ♀, s., and trying in vain to collect pollen; *Andrenidae:* (9) Agapostemon viridula F. ♂♀, s. and c. p.

Diptera — *Bombylidae:* (10) Exoprosopa decora Lw.; (11) Systoechus vulgaris Lw.— both s.

RUDBECKIA HIRTA L.— The stems grow from three to six decimetres high and bear conspicuous heads with bright yellow rays.

The ray-flowers are neutral. The flowers of the disc are hermaphrodite. The pollen is carried out on the hairy tips of the approximated style-divisions.

The tubes are slender and measure about four millimetres in length. The nectar, therefore, is accessible only to the longer and more slender tongues, but the pollen is easily accessible.

This plant holds an important place in the economy of *Calliopsis albitarsis* and *Andrena rudbeckiae.*

It blooms from June 1st to September 16th, though the last of July ends its maximum blooming period.

The list of visitors is the result of observations made on thirteen days, between June 9 and August 22:—

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s.; (2) Melissodes perplexa Cr. ♀, s. and c. p., freq.; (3) M. dentiventris Sm. ♀, s.; (4) M. obliqua Say ♂, s.; (5) Ceratina dupla Say ♀, s. and c. p.; (6) Megachile addenda Cr. ♀, s.; (7) M. pugnata Say ♀, c. p.; (8) M. montivaga Cr. ♀, c p.; (9) M. brevis Say ♂♀, s.; (10) Coelioxys altilis Cr. ♂, s.; (11) Epeolus lunatus Say ♂, s.; (12) Nomada annulata Sm. ♂♀, s.; (13) Calliopsis albitarsis Cr. ♂♀, s. and c. p., ab.; (14) C. illinoensis Cr.♂♀, s. and c. p., ab.; *Andrenidae:* (15) Andrena rudbeckiae Rob. ♂♀, s. and c. p., ab.; (16) Agapostemon viridula F. ♀, s. and c. p.; (17) Augochlora pura Say ♀, s. and c. p.; (18) Halictus sp. ♀, c. p.; (19) H. pectoralis Sm. ♂♀, s. and c. p., freq.; (20) H. ligatus Say ♀, s. and c. p.; (21) H. pilosus Sm. ♂♀, s. and c. p.; (22) H. pruinosus Rob. ♂, s.; (23) H. confusus Sm. ♂♀, s. and c. p.; *Eumenidae:* (24) Odynerus arvensis Sauss.; (25) O. anormis Say; *Bembecidae:* (26) Monedula pictifrons Sm.; *Sphecidae:* (27) Ammophila intercepta Lep., freq.; (28) A. pictipennis Walsh; (29) Priononyx thomae F. — all s.

Diptera — *Stratiomyidae:* (30) Odontomyia nigrirostris Lw., s.; *Bombylidae:* (31) Exoprosopa decora Lw.; (32) E. fascipennis Say; (33) Anthrax parvicornis Lw.; (34) Sparnopolius fulvus Wd. — all four s.; *Conopidae.* (35) Zodion fulvifrons Say, s.; *Syrphidae:* (36) Paragus tibialis Fll.; (37) Allograpta obliqua Say; (38) Mesograpta marginata Say, ab.; (39) Sphaerophoria cylindrica Say; (40) Eristalis dimidiatus Wd.; (41) E. latifrons Lw., ab.; (42) E. transversus Wd., ab.; (43) E. aeneus F.; (44) Helophilus latifrons Lw.; (45) Tropidia mamillata Lw.; (46) Syritta pipiens L.; *Tachinidae:* (47) Ocyptera euchenor Wlk., freq.; (48) Jurinia apicifera Wlk.; (49) Cuphocera ruficauda v. d. W.; (50) Acroglossa hesperidarum Will., freq.; *Anthomyidae:* (51) sp.; (52) Coenosia sp. — all s. or f. p.

Lepidoptera — *Rhopalocera:* (53) Argynnis cybele F.; (54) Phyciodes nycteis D.—H.; (55) P. tharos Dru.; (56) Liminitis disippus Gdt.; (57) Thecla calanus Hbn.; (58) Chrysophanus thoe B.—L.; (59) Pieris rapae L.; (60) Colias philodice Gdt.; (61) Pamphila peckius Kby.; (62) P. cernes B. — L.; *Heterocera:* (63) Scepsis fulvicollis Hbn.; (64) Plusia simplex Gn.— all s.

Coleoptera — *Buprestidae:* (65) Acmaeodera pulchella Hbst.; *Cerambycidae:* (66) Typocerus sinuatus Newm., freq.; *Chrysomelidae:* (67) Diabrotica atripennis Say; *Mordellidae:* (68) Mordella scutellaris F.; *Meloidae:* (69) Macrobasis unicolor Kby.; *Curculionidae:* (70) Centrinus scutellum-album Say — all f. p.

Rudbeckia triloba L.— The stems grow from six to fifteen decimetres high and bear numerous small heads with black-purple centers and yellow rays. The heads expand

four or five centimetres. The tubes of the disc-florets are very narrow and measure about three millimetres in length.

This species blooms from July 23 to October 16. The following list, which contains an interesting assemblage of long-tongued flies, was observed on eight days, between August 4 and September 14 :—

Hymenoptera — *Apidae:* (1) Bombus separatus Cr. ♂, s., one; (2) Melissodes obliqua Say ♀, s. and c. p.; (3) M. perplexa Cr. ♀, s. and c. p.; (4) M. confusa Cr. ♂, s.; (5) Epeolus mercatus F. ♂♀, s.; (6) Calliopsis illinoensis Cr. ♂♀, s. and c. p., ab.; (7) C. labrosus Rob. (MS) ♂♀, s. and c. p.; (8) C. compositarum Rob. ♂, s.; (9) C. asteris Rob. (MS) ♀, s. and c. p.; *Andrenidae:* (10) Andrena aliciae Rob. ♂♀, s. and c. p., freq.; (11) Halictus pectoralis Sm. ♀, s. and c. p., freq.; (12) H. coriaceus Sm. ♀, s.; (13) H. ligatus Say ♀, s.; (14) H. fasciatus Nyl. ♀, s.; (15) Colletes compacta Cr. ♀, s. and c. p.; (16) C. americana Cr. ♀, s. and c. p.; *Vespidae:* (17) Polistes pallipes Lep., s.; *Eumenidae:* (18) Odynerus arvensis Sauss., s.; *Sphecidae:* (19) Ammophila gracilis Lep., s.; *Scoliidae:* (20) Scolia bicincta F., s.; *Ichneumonidae:* (21) Exetastes suaveolens Walsh, s.

Diptera — *Empidae:* (22) Empis sp.; *Syrphidae:* (23) Eristalis transversus Wd.; *Bombylidae:* (24) Exoprosopa decora Lw.; (25) E. fascipennis Say; (26) Anthrax halcyon Say, freq.; (27) Sparnopolius fulvus Wd.; (28) Systropus macer F.; (29) Toxophora amphitea Wlk.; (30) Lepidophora aegeriiformis Westwood; *Tachinidae:* (31) Cuphocera ruficauda v. d. W.; (32) Epigrimyia polita Twns.; (33) Coronimyia geniculata Twns., ab.; (34) Siphoplagia anomala Twns.; *Dexidae:* (35) sp.; (36) Prosena sp., freq. — all s.

Lepidoptera — *Nymphalidae:* (37) Phyciodes tharos Dru.; (38) P. nycteis D.—H.; *Papilionidae:* (39) Pieris protodice B.—L.; (40) Colias philodice Gdt.— all s.

Coleoptera — *Mordellidae:* (41) Mordellistena sp.

Lepachys pinnata Torr. and Gray. — The plant grows about one metre high. The stem and branches bear single heads with conspicuous, drooping yellow rays. The ray-florets are neutral. The disc is oblong. The tubes of the disc-florets are two millimetres in length. The florets and the chaff, with its thickened tips, form a very compact mass which renders it easy for *Melissodes obliqua* to run around the heads and clean up the pollen in her copious scopae. This bee, though by no means the exclusive visitor, is by far the most abundant, being more common on this than any other flower. This *Melissodes* is the most important pollinator of *Lepachys pinnata*, and the plant in turn is the most important in the economy of the bee, being its chief source of pollen supply.

Lepachys pinnata blooms from July 4th to August 29. The list was observed on fifteen days between July 11th and August 9th:—

Hymenoptera — *Apidae:* (1) Melissodes sp. ♂♀, s. and c. p.; (2) M. dentiventris Sm. ♂, s.; (3) M. bimaculata Lep. ♂, s., ab.; (4) M. obliqua Say ♂♀, s. and c. p., very ab.; (5) M. aurigenia Cr. ♂♀, s., freq.; (6) M. perplexa Cr. ♂, s.; (7) Megachile latimanus Say ♂♀, s.; (8) M. pugnata Say ♀, s.; (9) M. inimica Cr. ♂♀, s., ab.; (10) M. addenda Cr. ♀, s.; (11) M. mendica Cr. ♀, s.; (12) M. brevis Say ♂, s.; (13) Alcidamea producta Cr. ♀, s.; (14) Coelioxys totoneca Cr. ♂, s.; (15) Epeolus remigatus F. ♂♀, s., ab.; (16) E. lunatus Say ♂♀, s., ab.; (17) E. mercatus F. ♀, s.; (18) E. fumipennis Say ♂, s.; *Andrenidae:* (19) Halictus lerouxii Lep. ♀, s. and c. p.; (20) H. ligatus Say ♂♀, s. and c. p., ab., (21) H. albipennis Rob. ♀, s. and c. p.; (22) Agapostemon radiatus Say ♂, s.; (23) Augochlora humeralis Pttn. ♂, s.; *Eumenidae:* (24) Odynerus sp.; (25) O. arvensis Sauss.; (26) O. anormis Say; *Bembecidae:* (27) Bembex nubillipennis Cr., ab.; (28) Monedula pictifrons Sm., freq.; *Sphecidae:* (29) Ammophila intercepta Lep.; (30) A. pictipennis Walsh; (31) Priononyx atrata Lep.; (32) P. thomae F. — all s.

Lepidoptera — *Rhopalocera:* (33) Phyciodes tharos Dru.; (34) Thecla humuli Harr.; (35) Lycaena comyntas Gdt. — all s.

Diptera — *Empidae*: (36) Empis sp.; *Bombylidae:* (37) Geron senilis F.; *Conopidae:* (38) Zodion leucostoma Will., freq.; *Muscidae acalyptratae:* (39) sp. — all s.

Coleoptera — *Buprestidae:* (40) Acmaeodera pulchella Hbst.; *Cerambycidae:* (41) Typocerus sinuatus Newm. — both f. p.

Helianthus mollis Lam. — The stems grow from six to ten decimetres high and bear rather large heads with yellow discs. The heads commonly look towards the east. They expand five or six centimetres or more. The disc-florets have tubes about six millimetres long.

Helianthus mollis blooms from July 21 to September 7, and on August 17 and 19, was found to be visited by:—

Hymenoptera — *Apidae:* (1) Bombus americanorum F. ♂☿, s., freq.; (2) Melissodes obliqua Say ♂♀, s. and c. p., freq.; (3) M. coloradensis Cr. ♂, s.; (4) Epeolus remigatus F. ♀, s., freq.; *Andrenidae:* (5) Agapostemon viridula F. ♂, s.

Diptera — *Bombylidae:* (6) Anthrax halcyon Say; (7) Systoechus vulgaris Lw., freq.; *Tachinidae:* (8) Siphoplagia anomala Twns. — all s.

Lepidoptera — *Papilionidae:* (9) Colias philodice Gdt., s.

Helianthus grosse-serratus Martens. — Visitors — observed on 16 days, between September 1 and October 4: —

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s., ab.; (2) Bombus separatus Cr. ♂☿, s.; (3) B. scutellaris Cr. ☿, s.; (4) B. pennsylvanicus

De G. ☿, s.; (5) B. americanorum F. ♂☿, s., ab.; (6) B. virginicus Oliv. ♀ ☿, s.; (7) Melissodes sp. ♀, s.; (8) M. coloradensis Cr. ♀, s. and c. p.; (9) M. obliqua Say ♀, s. and c. p., freq.; (10) M. perplexa Cr. ♀, s. and c. p., freq.; (11) M. dentiventris Sm. ♀, s. and c. p., freq.; (12) M. aurigenia Cr. ♂♀, s. and c. p., ab.; (13) M. desponsa Sm. ♀, s. and c. p.; (14) Megachile latimanus Say ♂♀, s. and c. p., ab.; (15) M. inimica Cr. ♀, s.; (16) M. brevis Say ♀, s. and c. p.; (17) M. optiva Cr. ♀, s.; (18) Coelioxys dubitata Sm. ♀, s.; (19) Epeolus remigatus F. ♀, s.; (20) E. mercatus F. ♀, s., freq.; (21) Nomada vincta Say ♂♀, s., freq.; (22) Calliopsis illinoensis Cr. ♀, s. and c. p.; (23) C. solidaginis Rob. ♀, s.; (24) Panurgus autumnalis Rob. (MS) ♀, s. and c. p., freq.; (25) Andrena helianthi Rob. ♂♀, s. and c. p., ab.; (26) A. pulchella Rob. ♀, s. and c. p., ab.; (27) Halictus ligatus Say ♀, s. and c. p.; (28) Agapostemon viridula F. ♂, s.; *Bembecidae:* (29) Bembex nubillipennis Cr., s.; *Sphecidae:* (30) Priononyx atrata Lep., s.

Diptera — *Bombylidae:* (31) Systoechus vulgaris Lw., freq.; (32) Sparnopolius fulvus Wd., ab.; (33) Exoprosopa decora Lw. — all s.; *Syrphidae:* (34) Syrphus americanus Wd.; (35) Eristalis tenax L.; (36) E. latifrons Lw., ab.; (37) E. transversus Wd.; (38) Helophilus latifrons Lw. — all s. and f. p.; *Tachinidae:* (39) sp., s.; *Muscidae:* (40) Lucilia cornicina F., s.; *Anthomyidae:* (41) sp., s.

Lepidoptera — *Rhopalocera:* (42) Danais archippus F., freq.; (43) Euptoieta claudia Cram.; (44) Argynnis cybele F.; (45) Pyrameis cardui L., freq.; (46) P. huntera F.; (47) Papilio philenor L.; (48) Meganostoma caesonia Stoll; (49) Colias philodice Gdt.; (50) Pyrgus tessellata Scud.; *Heterocera:* (51) Scepsis fulvicollis Hbn.; (52) Utetheisa bella L.; (53) Plusia simplex Gn. — all s.

Coleoptera — *Lampyridae:* (54) Chauliognathus pennsylvanicus De G.; *Chrysomelidae:* (55) Diabrotica longicornis Say; (56) D. 12-punctata Oliv. — all f. p.

HELIANTHUS STRUMOSUS L.— The heads expand five or six centimetres. The disc corollas measure six millimetres in length.

This Helianthus blooms from July 21 to September 3. The following visitors were taken on the flowers on August 22 and 24:—

Hymenoptera — *Apidae:* (1) Bombus separatus Cr. ♂, s.; (2) Melissodes obliqua Say ♂♀, s. and c. p., freq.; (3) Ceratina dupla Say ♀, s.; (4) Megachile petulans Cr. ♂, s.; (5) Epeolus remigatus F. ♀, s.; (6) E. mercatus F. ♂, s.; (7) Calliopsis labrosus Rob. (MS) ♀, s.; *Andrenidae:* (8) Andrena pulchella Rob. ♀, s., freq.; *Sphecidae:* (9) Ammophila intercepta Lep., s.

Diptera — *Bombylidae:* (10) Anthrax halcyon Say, s.; (11) Systoechus vulgaris Lw.; (12) Sparnopolius fulvus Wd.— all s.

Lepidoptera — *Rhopalocera:* (13) Phyciodes nycteis D.— H.; (14) Colias philodice Gdt.— both s.

HELIANTHUS TUBEROSUS L.— The stems grow two or three metres high and bear conspicuous yellow heads which expand from six to eight centimetres. The disc florets have corollas with tubes six milimetres long.

On fifteen days during the blooming time — August 13 to 26 — I observed the following visitors: —

Hymenoptera — *Apidae:* (1) Bombus vagans Sm. ♂, s.; (2) B. americanorum F. ♂☿, s. and c. p., freq.; (3) B. separatus Cr. ♂♀, s.; (4) Melissodes dentiventris Sm. ♂♀, s.; (5) M. obliqua Say ♀, s. and c. p., ab.; (6) M. coloradensis Cr. ♂♀, s. and c. p., freq.; (7) M. aurigenia Cr. ♂♀, s. and c. p., freq.; (8) M. confusa Cr. ♂, s.; (9) Megachile inimica Cr. ♀, c. p.; (10) M. brevis Say ♀, s.; (11) Epeolus lunatus Say ♀, s.; (12) E. remigatus F. ♀, s.; (13) Nomada vincta Say ♀, s.; (14) Calliopsis labrosus Rob. (MS) ♂♀, s. and c. p.; (15) C. rugosus Rob. (MS) ♂♀, s. and c. p, ab.; *Andrenidae:* (16) Andrena pulchella Rob. ♂♀, s. and c. p., ab.; (17) A. aliciae Rob. ♀, s. and c. p.; (18) Halictus coriaceus Sm. ♀, s. and c. p.; (19) H. pectinatus Rob. ♀, s. and c. p.; (20) H. ligatus Say ♀, s. and c. p.; *Philanthidae:* (21) Cerceris kennicottii Cr., s.; *Scoliidae:* (22) Scolia bicincta F., s.

Diptera — *Bombylidae:* (23) Exoprosopa fascipennis Say, freq.; (24) E. decora Lw.; (25) Anthrax halcyon Say, freq.; (26) Systoechus vulgaris Lw., freq.; (27) Sparnopolius fulvus Wd., ab. — all s.; *Syrphidae:* (28) Eristalis transversus Wd., s.; (29) E. tenax L., f. p.; *Muscidae:* (30) Lucilia cornicina F., s.; *Trypetidae:* (31) Trypeta finalis Lw.

Lepidoptera — *Rhopalocera:* (32) Phyciodes tharos Dru.; (33) Thecla m-album B. — L.; (34) Colias philodice Gdt.; (35) Pholisora catullus F. — all s.

Coleoptera — *Lampyridae:* (36) Chauliognathus pennsylvanicus De G.; *Chrysomelidae:* (37) Diabrotica longicornis Say; *Mordellidae:* (38) Mordella scutellaris F.; *Meloidae:* (39) Epicauta pennsylvanica De G. — all f. p.

VERBESINA HELIANTHOIDES Michx. — The plants grow from six to twelve decimetres high and have few heads, five or six centimetres wide. The rays are neutral, the disc-florets hermaphrodite.

The corollas are five or six mm. long.

The plant blooms from June 16 to August 10. The visitors were observed on July 5, 6, and 11 :—

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s., one; (2) Bombus americanorum F. ☿, s.; (3) Melissodes obliqua Say ♀, s.; (4) Ceratina dupla Say ♀, s.; (5) Megachile pollicaris Say ♂, s.; (6) M. pugnata Say ♂♀, s. and c. p., freq.; (7) M. brevis Say ♂♀, s. and c. p., freq.; (8) M. mendica Cr. ♀ s. and c. p.; (9) M. petulans Cr. ♂, s.; (10) Alcidamea producta Cr. ♀, c. p.; (11) Coelioxys sp. ♂, s.; (12) C. altilis Cr. ♂, s.; (13) Calliopsis albitarsis Cr. ♂, s.; *Andrenidae*; (14) Halictus lerouxii

Lep. ♀, s. and c. p.; (15) H. ligatus Say ♂, s.; (16) Augochlora similis Rob. ♀, s. and c. p.; (17) Agapostemon viridula F. ♀, s.; *Bembecidae:* (18) Monedula pictifrons Sm., s.; *Sphecidae;* (19) Ammophila gryphus Sm., s., freq.; (20) A. intercepta Lep., s., freq.; (21) A. pictipennis Walsh, s.

Diptera — *Bombylidae:* (22) Systoechus vulgaris Lw.; (23) Anthrax parvicornis Lw.; *Syrphidae:* (24) Eristalis transversus Wd. — all s.

Lepidoptera — *Ctenuchidae:* (25) Scepsis fulvicollis Hbn., s.

Coreopsis palmata Nutt. — The plants grow in small, thin patches; the stems rise about six decimetres high and bear conspicuous yellow heads about four centimetres wide. The ray florets are neutral, those of the disc, hermaphrodite.

The corollas are five or six millimetres long, the tube being very narrow below.

I have noted the plant in bloom from June 17 to July 8. The visitors were observed on June 27, 29 and July 1: —

Hymenoptera — *Apidae:* (1) Bombus americanorum F. ☿, s.; (2) Melissodes confusa Cr. ♂, s.; (3) Ceratina dupla Say ♀, s., freq.; (4) Megachile brevis Say ♀, s., freq.; (5) Nomada annulata Sm. ♀, s.; (6) Calliopsis albitarsis Cr. ♀, s.; (7) C. andreniformis Sm. ♀, s.; *Andrenidae:* (8) Halictus ligatus Say ♂♀, s. and c. p., freq.; (9) H. fasciatus Nyl. ♀, s.; (10) H. pilosus Sm. ♀, s. and c. p.; (11) Augochlora similis Rob. ♀, s. and c. p.; *Eumenidae:* (12) Odynerus anormis Say; *Sphecidae:* (13) Ammophila gryphus Sm.; (14) A. vulgaris Cr.; (15) A. intercepta Lep.; (16) A. pictipennis Walsh; (17) Priononyx thomae F.; *Braconidae:* (18) Toxoneura abdominalis Cr. — all s.

Diptera — *Stratiomyidae:* (19) Odontomyia nigrirostris Lw.; *Conopidae:* (20) Zodion fulvifrons Say; *Muscidae:* (21) Stomoxys calcitrans L.; (22) Lucilia sp.; *Muscidae acalyptratae:* (23) sp. — all s.

Lepidoptera — *Rhopalocera:* (24) Phyciodes tharos Dru.; (25) Colias philodice Gdt.; (26) Pamphila cernes B.— L. — all s.

Coleoptera — *Cerambycidae:* (27) Typocerus sinuatus Newm.; *Mordellidae:* (28) Mordella scutellaris F.; *Meloidae:* (29) sp. — all f. p.

Coreopsis tripteris L. — The stems grow from fifteen to twenty-five decimetres high and are terminated by corymbose clusters of small heads with yellow rays and dark-purple centers. The rays are neutral. The tubes of the disc florets are about six millimetres long, but a proboscis four millimetres long can obtain some of the nectar. The plants are generally scattered so that they do not attract insects in great numbers.

This species blooms later than the preceding — July 26 to September 26. The visitors were observed August 22, 24 and 30: —

Hymenoptera — *Apidae:* (1) Bombus americanorum F. ☿, s.; (2) Melissodes obliqua Say ♀, s. and c. p.; (3) M. dentiventris Sm. ♂, s., freq.; (4) Megachile montivaga Cr. ♀, s.; (5) Epeolus remigatus F. ♀, s.; (6) Calliopsis labrosus Rob. (MS) ♂♀, s.; *Andrenidae:* (7) Andrena pulchella Rob. ♀, s. and c. p.; (8) Halictus pectoralis Sm. ♀, s.; (9) H. ligatus Say ♀, s. and c. p.; *Sphecidae:* (10) Ammophila gryphus Sm., s.; *Scoliidae:* (11) Scolia bicincta F., s., freq.

Diptera — *Bombylidae:* (12) Anthrax halcyon Say; (13) Systoechus vulgaris Lw.; (14) Sparnopolius fulvus Wd.; (15) Lepidophora aegeriiformis Westwood; *Tachinidae:* (16) Coronimyia geniculata Twns. — all s.

Coreopsis aristosa Michx.— Visitors observed on fourteen days — August 2 to September 15:—

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s., ab.; (2) Bombus separatus Cr. ♂, s., freq.; (3) B. scutellaris Cr. ☿, s.; (4) B. americanorum F. ♂☿, s. and c. p., ab.; (5) B. virginicus Oliv. ♂♀☿, s. and c. p., ab.; (6) Melissodes bimaculata Lep. ♀, s.; (7) M. desponsa Sm. ♀, s. and c. p.; (8) M. dentiventris Sm. ♂♀, s. and c. p.; (9) M. aurigenia Cr. ♀, s. and c. p., freq.; (10) M. perplexa Cr. ♂♀, s. and c. p., ab.; (11) Ceratina dupla Say ♀, s. and c. p.; (12) Megachile brevis Say ♂♀, s. and c. p., freq.; (13) M. optiva Cr. ♀, s. and c. p.; (14) Heriades carinatum Cr. ♂, s.; (15) Epeolus mercatus F. ♂♀, s., freq.; (16) Calliopsis octomaculatus Rob. (MS) ♂♀, s. and c. p., ab.; (17) C. illinoensis Cr. ♂♀, s. and c. p., ab.; (18) C. rugosus Rob. (MS) ♀, s. and c. p.; (19) C. compositarum Rob. ♂, s.; (20) C. labrosus Rob. (MS) ♂♀, s. and c. p.; *Andrenidae:* (21) Andrena aliciae Rob. ♀, s. and c. p.; (22) Halictus coriaceus Sm. ♂, s.; (23) H. ligatus Say ♀, s.; (24) Agapostemon viridula F. ♂♀, s. and c. p.; (25) A. radiatus Say ♀, s. and c. p.; (26) Augochlora labrosa Say ♀, s.; (27) Colletes spinosa Rob. ♀, s.; (28) C. compacta Cr. ♂♀, s., freq.; *Vespidae:* (29) Vespa germanica F.; *Eumenidae:* (30) Odynerus tigris Sauss.; *Bembecidae:* (31) Bembex nubillipennis Cr.; (32) B. fasciata F.; (33) Bembedula ventralis Say; *Sphecidae:* (34) Ammophila intercepta Lep.; (35) Pelopoeus cementarius Dru.; *Scoliidae:* (36) Myzine sexcincta F.; (37) Scolia bicincta F., ab.; *Braconidae:* (38) sp.; *Ichneumonidae:* (39) Exetastes suaveolens Walsh — all s.

Diptera — *Bombylidae:* (40) Exoprosopa fasciata Mcq.; (41) E. fascipennis Say; (42) E. decora Lw.; (43) Anthrax halcyon Say; (44) Sparnopolius fulvus Wd., ab.; (45) Systropus macer F.; (46) Toxophora amphitea Wlk. — all s.; *Conopidae:* (47) Zodion fulvifrons Say, s.; *Syrphidae;* (48) Chrysogaster nitida Wd.; (49) Syrphus americanus Wd.; (50) Mesograpta polita Say; (51) Eristalis dimidiatus Wd., freq.; (52) E. latifrons Lw.; (53) E. transversus Wd.— all s. or f. p.; *Dexidae:* (54 and 55) spp.; (56) Prosena sp.; (57) Scotiptera parvicornis Twns. — all s.; *Tachinidae:* (58 and 59) spp., s., freq.; (60) Jurinia smaragdina Mcq., freq.; (61) Echinomyia robusta Wd., freq.; (62) Siphoplagia anomala Twns., freq.; (63) Miltogramma argentifrons Twns.; (64) Acroglossa hesperidarum Will.— all s.; *Sarcophagidae:* (65) Sarcophaga sp., s.; *Muscidae:* (66) Lucilia caesar L., s.; (67) Compsomyia macellaria F., s.; *Anthomyidae:* (68) Chortophila sp., s.

Lepidoptera — *Rhopalocera:* (69) Danais archippus F., freq.; (70) Argynnis cybele F.; (71) Phyciodes tharos Dru.; (72) Pyrameis cardui L., freq.; (73) Limenitis disippus Gdt.; (74) L. ursala F.; (75) Papilio philenor L.; (76) P. asterias F.; (77) Pieris rapae L.; (78) Colias philodice Gdt.; (79) Pamphila cernes B. — L.; (80) Nisoniades juvenalis F.; (81) Eudamus tityrus F.; *Heterocera:* (82) Heliothis armiger Hbn. — all s.

Coleoptera — *Lampyridae:* (83) Chauliognathus pennsylvanicus De G., ab., pairing; *Chrysomelidae:* (84) Chrysomela similis Rog.; (85) Diabrotica 12-punctata Oliv.; *Meloidae:* (86) Epicauta cinerea Forst.; (87) E. pennsylvanica De G.; *Rhipiphoridae:* (88) Myodites sp. — all f. p.

Hemiptera — *Pentatomidae:* (89) Euschistus, sp., s.

Bidens chrysanthemoides Michx. — Visitors observed on September 20th:—

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s., ab.; (2) Bombus americanorum F. ♂ ☿, s., freq.; (3) Melissodes dentiventris Sm. ♀, s.; (4) M. aurigenia Cr. ♀, s. and c. p.; (5) M. perplexa Cr. ♂ ♀, s. and c. p., freq.; (6) Ceratina dupla Say ♀, s.; (7) Megachile latimanus Say ♀, s. and c. p.; (8) M. brevis Say ♂ ♀, s. and c. p., freq.; (9) M. mendica Cr. ♂, s.; (10) M. petulans Cr. ♂, s.; (11) Epeolus mercatus F. ♀, s.; *Andrenidae:* (12) Andrena aliciae Rob. ♀; (13) Halictus ligatus Say ♂, s.; (14) H. confusus Sm. ♀, s. and c. p.; (15) Colletes compacta Cr. ♂ ♀, s. and c. p., freq.; *Vespidae:* (16) Polistes metricus Say, s.; *Eumenidae:* (17) Eumenes fraternus Say, s.; *Scoliidae:* (18) Scolia bicincta F., s., freq.; *Ichneumonidae:* (19) Exetastes suaveolens Walsh, s.

Lepidoptera — *Rhopalocera:* (20) Danais archippus F., ab.; (21) Phyciodes tharos Dru.; (22) Pyrameis huntera F.; (23) P. atalanta L.; (24) Limenitis disippus Gdt.; (25) Chrysophanus thoe B.— L.; (26) Colias philodice Gdt., freq.; (27) Pamphila campestris Bdv. v. huron Edw.; (28) P. phylaeus Dru.; *Heterocera:* (29) Scepsis fulvicollis Hbn.; (30) Feltia subgothica Steph.; (31) Plusia simplex Gn.; (32) Heliothis armiger Hbn.; (33) H. dipsaceus L.—all s.

Diptera — *Bombylidae:* (34) Anthrax halcyon Say, s.; (35) Systoechus vulgaris Lw., s.; (36) Sparnopolius fulvus Wd., s., freq.; *Syrphidae:* (37) Mesograpta marginata Say, s.; (38) Eristalis dimidiatus Wd., s., ab.; (39) E. transversus Wd., s., ab.; (40) Helophilus similis Mcq.; *Tachinidae:* (41) Jurinia smaragdina Mcq., s., freq.; (42) Siphoplagia anomala Twns.; *Muscidae:* (43) Lucilia cornicina F., s., freq.; (44) Compsomyia macellaria F., s., freq.; *Anthomyidae:* (45) Hydrophoria sp.

Coleoptera — *Lampyridae:* (46) Chauliognathus pennsylvanicus De G., s. and f. p., ab.; *Chrysomelidae:* (47) Diabrotica 12-punctata Oliv., f. p.

Helenium autumnale L. — Visitors observed on September 15 and 22:—

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s. and c. p.; (2) Bombus separatus Cr. ♀, s.; (3) B. scutellaris Cr. ♂, s.; (4) B. americanorum F. ♂ ☿, s., freq.; (5) B. virginicus Oliv. ♂ ☿, s., ab.; (6) Melissodes denti-

ventris Sm. ♀, c. p.; (7) M. aurigenia Cr. ♂, s.; (8) M. perplexa Cr. ♀, s. and c. p., ab.; (9) M. confusa Cr. ♀, s. and c. p.; (10) Megachile latimanus Say ♀, s.; (11) M. brevis Say ♀, s. and c. p., ab.; (12) Coelioxys altilis Cr. ♀, s.; (13) Epeolus mercatus F. ♀, s., ab.; *Andrenidae:* (14) Agapostemon viridula F. ♂, s.; (15) Halictus fasciatus Nyl. ♀, s. and c. p.; (16) Colletes compacta Cr. ♀, s. and c. p.; *Vespidae:* (17) Vespa germanica F.; (18) Polistes pallipes Lep.; *Bembecidae:* (19) Bembex fasciata F.; (20) Bembedula ventralis Say, freq.; *Sphecidae:* (21) Ammophila gryphus Sm.; (22) A. intercepta Lep.; (23) Priononyx atrata Lep. — all s.

Lepidoptera — *Rhopalocera:* (24) Phyciodes tharos Dru.; (25) Colias philodice Gdt.; (26) Pamphila cernes B. — L.; *Heterocera:* (27) Scepsis fulvicollis Hbn. — all s.

Diptera — *Bombylidae:* (28) Anthrax halcyon Say; (29) Sparnopolius fulvus Wd.; *Syrphidae:* (30) Syrphus arcuatus Fll. — all s.

Coleoptera — *Lampyridae:* (31) Chauliognathus pennsylvanicus De G., f. p., ab.; *Meloidae:* (32) Epicauta pennsylvanica De G., f. p.

Hemiptera — *Pentatomidae:* (33) Euschistus fisilis Uhl., s.

Cnicus altissimus Willd. — Visitors observed on August 22nd and 24th: —

Hymenoptera — *Apidae:* (1) Bombus americanorum F. ♂☿; (2) B. pennsylvanicus De G. ☿; (3) Melissodes desponsa Sm. ♂ — all s.

Lepidoptera — *Rhopalocera:* (4) Argynnis cybele F.; (5) Papilio troilus L. — both s.

Cnicus altissimus Willd. *v.* discolor Gray. — The following visitors were observed on September 3, 6, 7 and 15: —

Hymenoptera — *Apidae:* (1) Bombus separatus Cr. ♂, s.; (2) B. scutellaris Cr. ♂☿, s. and c. p.; (3) B. pennsylvanicus De G. ♂♀☿, s. and c. p.; (4) B. americanorum F. ♂♀☿, s. and c. p., ab.; (5) B. virginicus Oliv. ☿, s. and c. p.; (6) Melissodes desponsa Sm. ♀, s. and c. p., ab.; (7) M. obliqua Say ♀, s. and c. p.; (8) Megachile latimanus Say ♀, s. and c. p., freq.; *Andrenidae*: (9) Colletes eulophi Rob. ♀, c. p., one.

Lepidoptera — *Nymphalidae*: (10) Argynnis idalia Dru., s.

Diptera — *Bombylidae* (11) Exoprosopa fasciata Mcq., s.

Cnicus lanceolatus Hoffm.* — "Nat. from Eu." — Visitors observed on seven days between July 23 and October 7: —

Hymenoptera — *Apidae:* (1) Bombus americanorum F. ♂♀☿, s. and c. p., ab.; (2) B. virginicus Oliv. ☿, s.; (3) B. pennsylvanicus De G. ☿, s.; (4) B. separatus Cr. ♂☿, s., freq.; (5) Melissodes desponsa Sm. ♂♀, s. and

* See Müller: Fertilization of Flowers, Weitere Beobachtungen & Alpenblumen.

c. p., ab.; (6) M. obliqua Say ♂♀, s., freq.; (7) M. coloradensis Cr. ♂, s.; (8) M. bimaculata Lep. ♀, s.; (9) M. dentiventris Sm. ♂, s.; (10) M. aurigenia Cr. ♂, s.; (11) Megachile latimanus Say ♀, s. and c. p., freq.; (12) M. sexdentata Rob. (MS) ♂, s.; (13) Epeolus remigatus F. ♀, s.; *Andrenidae:* (14) Halictus ligatus Say ♀, c. p., ab.; (15) H. pilosus Sm. ♀, c. p.; (16) Agapostemon viridula F. ♀, s.; (17) A. radiatus Say ♂, s.

Lepidoptera — *Rhopalocera* (18) Danais archippus F.; (19) Phyciodes tharos Dru.; (20) Pieris protodice B.— L.; (21) Colias philodice Gdt.; (22) Papilio turnus L. and glaucus L.; (23) P. asterias F.; (24) P. troilus L.; (25) Pamphila peckius Kby.; (26) P. cernes B.— L.; (27) Eudamus bathyllus S. and A.; *Heterocera* (28) Scepsis fulvicollis Hbn.— all s.

Diptera — *Bombylidae:* (29) Exoprosopa fasciata Mcq.; (30) Systoechus vulgaris Lw., freq.; *Conopidae:* (31) Physocephala tibialis Say — all s.

Krigia amplexicaulis Nutt. — The plants are often collected in conspicuous patches. The stems grow from three to six decimetres high and bear several yellow heads which expand about three centimetres.

The flowers are all ligulate. The pollen becomes attached to the hairy portion of the style and is thus carried upwards and exposed. The corolla tubes are narrow and measure about two millimetres in length.

The following visitors were observed on May 30th: —

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s. and c. p., one; (2) Synhalonia speciosa Cr. ♂, s.; (3) Ceratina dupla Say ♂♀, s., freq.; (4) Alcidamea producta Cr. ♂, s.; (5) Osmia albiventris Cr. ♀, s.; (6) Nomada annulata Sm. ♂, s., freq.; *Andrenidae:* (7) Halictus ligatus Say ♀, s. and c. p., ab.; (8) H. fasciatus Nyl. ♀, s. and c. p.; (9) H. pilosus Sm. ♀, s. and c. p., freq.; (10) H. albipennis Rob. ♀, s. and c. p., ab.; (11) H. confusus Sm. ♀, s. and c. p., freq.; (12) Augochlora similis Rob. ♀, s. and c. p., ab.; (13) Agapostemon viridula F. ♀, s. and c. p.; (14) Prosopis affinis Sm. ♂, s. and f. p., freq.; (15) P. pygmaea Cr., f. p.; *Eumenidae:* (16–18) Odynerus spp., s., freq. (19) O. foraminatus Sauss., s.; (20) O. anormis Say, s., freq.; *Crabronidae:* (21) Crabro interruptus Lep., s.

Diptera — *Conopidae:* (22) Zodion fulvifrons Say, s.; *Syrphidae:* (23) Mesograpta marginata Say; (24) Sphaerophoria cylindrica Say; (25) Eristalis transversus Wd.; (26) Helophilus similis Mcq.; *Tachinidae:* (27) Cistogaster occidua Wlk.; *Muscidae:* (28) Lucilia cornicina F. — all s. or f. p.

Lepidoptera — *Rhopalocera:* (29) Danais archippus F.; (30) Phyciodes tharos Dru.; (31) Papilio asterias F.; (32) Pamphila peckius Kby. — all s.

Coleoptera — (33) sp.; *Coccinellidae:* (34) Megilla maculata De G.; *Chrysomelidae:* (35) Diabrotica 12-punctata Oliv., freq. — all f. p.

TABLE I.

	Apidae.	Andrena.	Other andrenidae.	Other hymenoptera.	Diptera.	Coleoptera.	Other insects.	Total.	Bees.	Other hymenoptera.	Diptera.	Other insects.
Amelanchier canadensis..........	3	9	6	1	6	..	....	25	18	1	6	...
Prunus americana................	1	4	5	....	16	1	4	31	10	....	16	5
Geum vernum	..	..	1	....	..	..	....	1	1	....	..	....
Pyrus coronaria.................	6	..	....	....	..	..	2	8	6	....	..	2
Crataegus coccinea v. mollis.....	3	8	8	4	15	4	1	43	19	4	15	5
coccinea.............	5	8	6	3	22	6	2	52	19	3	22	8
Fragaria virginiana v. illinoensis..	3	..	9	....	5	..	....	17	12	....	5	....
Prunus serotina.................	7	9	11	2	21	1	2	53	27	2	21	3
Crataegus crus-galli............	10	9	13	8	20	3	3	66	32	8	20	6
Rubus villosus..................	4	2	3	....	2	..	....	11	9	....	2	....
occidentalis..............	..	1	....	1	..	..	....	2	1	1	..	....
Potentilla canadensis...........	8	1	8	4	7	..	1	29	17	4	7	1
Rosa humilis....................	6	..	3	....	..	2	....	11	9	....	..	2
setigera	2	..	....	....	..	1	....	3	2	....	..	1
Spiraea aruncus.................	..	4	2	....	3	15	....	24	6	....	3	15
Geum album	2	..	8	6	3	2	1	22	10	6	3	3

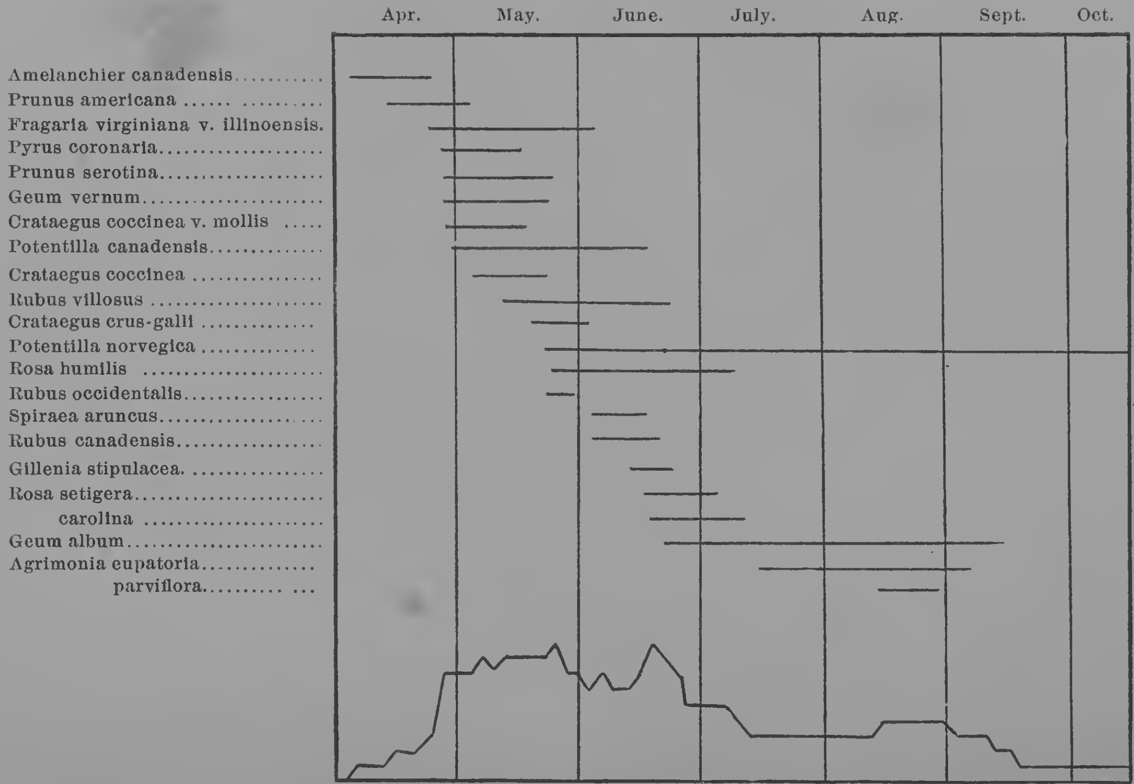
Apr.
May.
June.
July.
Aug.
Sept.
Oct.
Amelanchier canadensis
Prunus americana
Fragaria virginiana v. illinoensis.
Pyrus coronaria
Prunus serotina
Geum vernum
Crataegus coccinea v. mollis
Potentilla canadensis
Crataegus coccinea
Rubus villosus
Crataegus crus-galli
Potentilla norvegica
Rosa humilis
Rubus occidentalis
Spiraea aruncus
Rubus canadensis
Gillenia stipulacea.
Rosa setigera
carolina
Geum album
Agrimonia eupatoria
parviflora

TABLE II.

TABLE III.

		Bees.	Other hymenoptera.	Diptera.	Coleoptera.	Other insects.	Total.
Prunus communis	Low Germany.	15	1	10	1	1	28
padus	"	1	....	2	4	....	7
domestica, avium, cerasus (mixed list)	"	8	....	3	..	3	14
avium	"	5	....	..	2	...	7
armenica	"	5	1	..	..	....	6
americana	Illinois	10	....	16	1	4	31
serotina	"	27	2	21	1	2	53
Spiraea ulmaria	Low Germany.	7	6	10	12	....	35
"	Alps	..	....	..	1	....	1
"	Pyrenees	1	....	..	2	....	3
filipendula	Low Germany.	2	....	4	4	....	10
salicifolia, ulmifolia, sorbifolia (mixed)	"	20	15	46	25	4	110
aruncus	"	4	3	2	6	....	15
"	Alps	..	....	..	1	....	1
"	Illinois	6	....	3	15	....	24
Rubus fruticosus	Low Germany.	40	8	18	20	8	94
"	Pyrenees	3	....	1	1	1	6
idaeus	Low Germany.	11	2	2	2	....	17
"	Alps	7	1	1	..	1	10
saxatilis	"	3	....	1	..	....	4
villosus	Illinois	9	....	2	..	....	11
occidentalis	"	1	1	..	..	....	2
Geum rivale	Low Germany.	13	....	1	1	....	15
"	Alps	2	...	..	..	....	2
urbanum	Low Germany.	..	....	1	1	....	2
montanum	Alps	3	....	19	1	4	27
"	Pyrenees	1	2	4	..	....	7
vernum	Illinois	1	....	..	..	....	1
album	"	10	6	3	2	1	22
Fragaria virginiana v. illinoensis	"	12	....	5	..	....	17
vesca	Low Germany.	9	2	11	7	1	30
"	Alps	4	2	8	2	1	17
"	Pyrenees	..	1	..	1	....	2
elatior	Alps	..	1	5	1	1	8

TABLE IV.

		Bees.	Other hymenoptera.	Diptera.	Coleoptera.	Other insects.	Total......
Potentilla verna	Low Germany.	21	1	9	2	....	33
" and alpestris	Alps	13	4	29	1	2	49
"	Pyrenees	6	....	3	..	1	10
alpestris	"	1	....	2	..	....	3
reptans	Low Germany.	14	2	5	1	....	22
"	Pyrenees	..	....	1	..	....	1
anserina	Low Germany.	5	3	2	3	1	14
"	Alps	1	....	..	..	....	1
fruticosa	Low Germany.	2	2	16	2	....	22
tormentilla	"	3	....	4	..	1	8
"	Alps	..	....	1	1	2	4
"	Pyrenees	..	....	4	..	....	4
argentea	Low Germany.	8	1	4	3	....	16
minima	Alps	..	....	2	..	1	3
salisburgensis	"	4	....	15	2	3	24
aurea	"	5	2	27	3	15	52
grandiflora	"	8	4	16	4	13	45
caulescens	"	2	....	1	..	....	3
alchemilloides	Pyrenees	..	....	7	..	....	7
fragariastrum	"	..	1	1	..	1	3
rupestris	"	..	....	10	..	....	10
canadensis	Illinois	17	4	7	..	1	29
Agrimonia eupatoria	Low Germany.	1	....	10	..	....	11
Rosa canina	"	7	....	2	15	....	24
centifolia	"	11	3	5	16	....	35
rubiginosa	"	2	....	1	3	....	6
alpina	Alps	1	....	..	..	....	1
" ?	Pyrenees	..	....	2	..	....	2
sp.	"	..	....	1	..	....	1
humilis	Illinois	9	....	..	..	2	11
setigera	"	2	....	..	1	....	3
Pyrus malus	Low Germany.	9	1	6	..	....	16
communis	"	7	3	16	4	1	31
aucuparia	"	11	3	14	18	....	46
coronaria	Illinois	6	..	..	..	2	8
Crataegus coccinea	"	19	3	22	6	2	52
" v. mollis	"	19	4	15	4	1	43
crus-galli	"	32	8	20	3	3	66
oxycantha	Low Germany.	20	....	26	16	....	62
"	Pyrenees	1	....	2	1	....	4
Amelanchier vulgaris (Aronia rotundifolia)	Alps	..	1	6	7	....	14
canadensis	Illinois	18	1	6	..	....	25

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CHARLES ROBERTSON.

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305

FLOWERS AND INSECTS.*

CONTRIBUTIONS TO AN ACCOUNT OF THE ECOLOGICAL RELATIONS OF THE ENTOMOPHILOUS FLORA AND THE ANTHOPHILOUS INSECT FAUNA OF THE NEIGHBORHOOD OF CARLINVILLE, ILLINOIS.

CHARLES ROBERTSON.

The following paper belongs with a series begun in the Botanical Gazette, Vol. XIV, May, 1889, which has reached the fifteenth number in the Gazette for February, 1896. The papers on Umbelliferae and Asclepiadaceae to Scrophulariaceae, in Vol. V, 449–460, 569–598, and on Labiatae and Rosaceae and Compositae, in Vol. VI, 101–131, 435–480, of these Transactions, as well as a paper on the Philosophy of Flower Seasons, in the American Naturalist, XXIX, 97–117, Feb., 1895, are parts of the same series. Unless otherwise stated, the observations were made in the neighborhood of Carlinville, Illinois, and within the limits of Macoupin County.

In making up the indexes to the literature of the several genera, use has been made of the bibliography compiled by D'Arcy W. Thompson, published in the translation of Müller's Befruchtung der Blumen, and giving titles of books and papers published up to 1883; of MacLeod's continuation of Thompson's list for the period 1883–1889, Bot. Jaarboek, 1890; of the abstracts by Müller and Dalla Torre in Just's Bot. Jahresbericht, those of Ludwig and others in the Bot. Centralblatt and those of Loew in the recent work now to be mentioned. Next in importance to the translation of Müller's Befruchtung der Blumen is Loew's Blütenbiologische Floristik des mittleren und nördlichen Europa sowie Grönlands — Systematische Zusammenstellung des in den letzen zehn

* Presented by title to the Academy of Science of St. Louis, April 6, 1896.

Jahren veröffentlichten Beobachtungsmaterials. Besides a slight German bias it must be used with caution on account of its time limit. I have had trouble with it because it mentions an author's name without citing the paper in which the observations are recorded.

For access to much of the literature I am indebted to the authorities of the Missouri Botanical Garden. Owing to the interest Professor Trelease has taken in the subject, the library probably contains the best collection of the literature of pollination in this country, and that, too, in the most convenient form for consultation. It is highly desirable to make this collection as complete as possible.

In the determination of Hymenoptera I have been aided by Mr. E. T. Cresson, W. H. Ashmead, L. O. Howard and W. J. Fox; in Diptera by Dr. S. W. Williston, C. H. T. Townsend and D. W. Coquillett; in Lepidoptera by Prof. G. H. French and C. A. Hart; in Coleoptera by Mr. Hart, Chas. Liebeck, through Entomological News, and S. Henshaw; in Hemiptera by Mr. P. R. Uhler and Mr. Hart.

HEPATICA Dill.— Sprengel (1) regarded *H. triloba* as a pollen-flower adapted to bees, and his view that the flower contained no nectar is confirmed by Axell (3) Müller (4) and Loew (8). Müller saw *Eristalis tenax* frequently feeding upon the pollen and hive-bees collecting it. He also notes that the male of *Osmia rufa* vainly sought for nectar, and that a butterfly, *Colias rhamni*, rested upon the flowers and probed for nectar upon different parts of the receptacle. Loew accounts for the visits of *Osmia rufa* as a result of a scarcity of food or as being in the search of the female. I have observed that when male bees fly about flowers looking for the female, they only do so about flowers upon which the female occurs, and they seldom alight. I make it a rule to capture these male bees and to watch the flowers for the visits of the females to which they belong.

Müller (6) goes to an extreme in mentioning *Hepatica* as an example of the blue flowers specially attractive to the highest specialized bees. The color is commonly quite pale, and the indications seem to point to an adaptation to the least special-

ized bees. The flowers are perfect and homogamous, but rare cases of gynomonoecism and gynodioecism have been recorded by Irmisch (2), Schröter (9), Calloni (10) and Schulz (11). The perfect flowers are spontaneously self-pollinated after the innermost anthers have begun to dehisce (Kerner 12).

HEPATICA ACUTILOBA DC.—*H. acuta* (Ph.) Britton.—The plants are common on hill-sides and bloom quite early — March 18th to April 19. The scapes rise 1-2 dm. high and bear erect flowers with about six sepals, which are blue, pinkish or white, expanding horizontally so that the flowers measure about 25 mm. across. Commonly several scapes are near together, and the plants, having no competitors to overshadow them, are quite conspicuous. The flowers close at night and open in the morning, the old ones persisting long enough to increase the attractiveness of the patches.

As stated above, *H. triloba* is considered to be without nectar, and I could not satisfy myself of its presence in this species either by sight, taste or test for sugar in water in which the flowers had been immersed. In spite of the failure to discover its presence I am inclined to suspect that it occurs in a thin layer, for all of the insects mentioned in the list thrust their proboscides about the bases of the filaments, except *Syrphus americanus*. On the other hand none of them were feeding upon the pollen, or collecting it, except the three Syrphidae and the hive-bee, which is not indigenous. The receptacle is covered with papillae which may secrete nectar. Unless they do, I can understand neither why they are present and so strongly developed, why the filaments are separated in such a way as to make room for them, nor the behavior of the insects. In *Anemone nemorosa*, which is also said to be devoid of nectar, Bonnier* states that similar papillae secrete nectar in minute drops.

The early flowers with their abundant exposed pollen, and possibly convenient nectar, are adapted to the less specialized bees, *Andrenidae*, though often also visited by Syrphidae and other insects. With rare exceptions, the visitors consist of a few individuals of the commonest insects flying at the

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* Les Nectaires, 141.

time. The following list was observed on March 21 and 29, and April, 4: —

Bees — *Apidae:* (1) Apis mellifica L. ☿, s. & c. p., freq.: (2) Ceratina tejonensis Cr. ♂, s.; *Andrenidae:* (3) Halictus sp. ♀, s.; (4) H. confusus Sm. ♀, s.; (5) H. stultus Cr. ♀, s.; (6) Andrena vicina Sm. ♂♀, s.; (7) A. erythronii Rob. ♂, s.; (8) A. mandibularis Rob. ♂, s.; (9) A. flavoclypeata Sm. ♀, s.; (10) A. rugosa Rob. ♂♀, s., freq.; (11) Colletes inaequalis Say ♂, s.

Flies — *Bombylidae:* (12) Bombylius major L., s., freq.; *Syrphidae:* (13) Syrphus americanus Wd., f. p.; (14) Eristalis dimidiatus Wd., s. & f. p.; (15) Brachypalpus frontosus Lw., s. & f. p., freq.; *Tachinidae:* (16) Gonia frontosa Say, s.; *Muscidae:* (17) Lucilia cornicina F., s., freq.; *Anthomyidae:* (18) Phorbia fusciceps Zett., s.

On the literature of *Hepatica* see:—

(1) Sprengel, Das entdeckte Geheimniss, 31, 291–2. 1793. *Anemone hepatica.*— (2) Irmisch, Montröse Anemonenblüthen. Bot. Zeit. 1848: 217–18. *A. hepatica.*— (3) Axell, Om anordningarna för de fanerogama växternas befruktning, 104. 1869. *Anemone hepatica.*— (4) Müller, Weitere Beobachtungen. I: 43. Verh. naturhist. Vereins preuss. Rheinl. u. Westfalens 1878.— (5) Hildebrand, Die Farben der Blüthen in ihrer jetzigen Variation und früheren Entwickelung, 25, 28. 1879. *H. triloba*, cyanic. (Just 7[1]: 110).— (6) Müller, Die Stellung der Honigbiene in der Blumenwelt. Bienenzeit. 38: No. 10. 1882. (Just 9[1]: 499).— (7) Müller, Fertilization of Flowers, 71. 1883. *H. triloba.*— (8) Loew, Blumenbesuch von Insekten an Freilandpflanzen. Jahrb. Bot. Gartens Berlin 3: 114 (46). 1884.— (9) Schröter, Gynodioecisme chez Anemone hepatica. Arch. sci. phys. et nat. Geneva 14: 283. 1885.— (10) Calloni, Fleurs unisexuées et mouvement spontané des etamines dans l'Anemone hepatica. Arch. sci. phys. et. nat. III. 13: 409. 1885. (Just 13[1]: 751) — (11) Schulz. Beiträge zur Kenntniss der Bestäubungseinrichtungen und Geschlechtsvertheilung bei den Pflanzen. 2: 178. 1890.— (12) Kerner, Pflanzenleben 2: 126, etc. 1891. — (13) Hansgirg, Neue biologische Mittheilungen. Bot. Centralblatt 52: 386. 1892. *H. angulosa.* — (14) Loew, Blütenbiologische Floristik, 177, 377. 1894. *H. triloba.*

Asimina triloba Dunal. — Common Papaw — Delpino (1–4) has given so complete an account of this flower that there is hardly anything new that can be said about it. It is our best example of a flower adapted to flesh-flies (sapromyiophilous). It is pendulous, broad bell-shaped, with dark purple color and an odor which Delpino compares to that of leaven. The short-lived stigmas protrude from the hemispherical mass of stamens and are receptive before the latter discharge, so that we have a very well marked case of proterogyny. The three outer petals are larger and form the most

conspicuous parts. The three inner ones secrete nectar on their roughened inner faces, and are shaped and disposed so as to require the insects to come in contact with the anthers and stigmas. At first they are not so widely expanded, and this is important, since, when the flies crawl in, they are more apt to touch the stigmas, which are much fewer than the anthers and occupy a more limited and central position. Flies land upon the backs of the petals and crawl around to the underside, so that they strike the anthers and stigmas with their backs.

Asimina is an American genus, but there seems to be no reason why plants transferred to Europe should not be expected to show a quite natural assemblage of visitors, at least in the case of the species in question, since they would become exposed to a similar insect fauna. At Firenze, Delpino captured on the flowers a number of flies, which were determined by Rondani as follows :—

Muscidae: (1) Calliphora erythrocephala Mgn.; (2) Lucilia sericata Mgn.; (3) Cyrtoneura pasquorum Mgn.; (4) C. stabulans Fll.; (5) C. assimilis Fll.; *Anthomyidae:* (6) Homalomyia prostrata Rossi; *Ortalidae:* (7) Platystoma umbrarum Mgn.

Delpino did not seem to hold that the flower was adapted to flesh-flies until later (4). The following list observed on May 5th confirms this view. The trees are common on creek banks and bloom from April 22 to May 15.

Syrphidae: (1) Syrphus americanus Wd., one; *Tachinidae:* (2) Masicera sp., one; *Sarcophagidae:* (3) Cynomyia mortuorum L., freq.; (4) Sarcophaga aegra Wlk.; (5) Helicobia sp.; (6) H. helicis Twns.; *Muscidae:* (7) Lucilia caesar L.; *Anthomyidae:* (8) Phorbia fusciceps Zett. ; *Cordyluridae:* (9) Scatophaga squalida Mgn.

On the pollination of *Asimina triloba* see:—

(1) Delpino, Ulteriori osservazioni. Pt. I: 231, 242. Pt. II. fasc. 2: 24, 53, 94, 176, 178, 214, 301, 314. Atti d. soc. Ital. d. Sci. Milano 12: 221, 232. 1869. 16: 172–3, 201, 242, 324, 326. 1873. 17:—. 1874.—(2) Hildebrand, F. Delpino's Weitere Beobachtungen über die Dichogamie im Pflanzenreich. Bot. Zeit. 28: 672. 1870.—(3) Müller, Fertilization of Flowers, 90. 1883.—(4) Delpino, Sulla impollinazione dell' Arum Dracunculus. Malpighia 3: 389 (5). 1890. (Just 18[1]: 470).

PODOPHYLLUM L.— Loew (1) regards the two species of this genus as pollen-flowers. They are devoid of pathfinders.

The Himalayan *P. emodi* Wallr. resembles our species in a general way. It expands from 4 to 5 c. m. and has six petals and six stamens. The ovary is about 16 mm. long and bears a large stigma with six irregular lobes. The stamens are only 10 mm. long, so that self-pollination can hardly occur except as a result of irregular behavior on the part of the insect visitors.

PODOPHYLLUM PELTATUM L.— May Apple — The flower stem rises from a creeping rootstock to an height of about 3 d. m. and is terminated by two peltate leaves, between which is situated a single flower, which looks outwards and a little downwards. The flower is white and expands from 5 to 9 c. m. The petals are six to nine and the stamens 12 to 18. As a rule the anthers do not reach as far as the stigma, but sometimes their tips touch its edge so as to effect spontaneous self-pollination.

The flower seems to be devoid of nectar. I have watched it frequently, but have seldom seen it visited. A single hive-bee, *Apis mellifica* L. ☿, was observed collecting the pollen, but it is not a native insect. Two bumble-bees, *Bombus americanorum* F. ♀ and *B. separatus* Cr. ♀, probed about the bases of the filaments as if trying to find nectar, but did not try to collect the pollen. Another long-tongued bee, *Synhalonia frater* Cr. ♂, also sought for nectar.

The pollen protecting arrangements mentioned by Kerner (2) I think are quite imaginary.

The plant is common and blooms from April 26th to May 19th.

On the literature of *Podophyllum* see :—

(1) Loew, Blüthenbiologische Beiträge I. Pringsheim's Jahrbücher 22:452–3 (8–9). 1891. *P. emodi, peltatum.*— (2) Kerner, Pflanzenleben 2:126. 1891. (Just 17 :529.)

SOLEA CONCOLOR GING.— Green Violet — The plant is rare in my neighborhood, there being, as far as I have observed, but one station for it. It grows in woods, in somewhat shady situations, and is the latest of the family to bloom, its season being from April 30 to May 30. The stems grow several decimetres high and bear small greenish flowers, which are

pendulous, or nearly so. The flowers are rather inconspicuous and are partly concealed by the leaves, but there is an abundance of nectar. The lower petal is quite large. It is notched at the apex and bears a longitudinal groove which terminates in a blunt spur. The spur conceals the nectar, which is secreted by a large gland formed by a union of the two basal processes of the two lower stamens. The stamens are united into a tube enveloping the pistil, their cone-shaped tips receiving the loose pollen. Near the tip, the style is bent aside so that the stigma is placed in the groove of the lower petal. When a bee lands upon the lower petal, to which it clings, its proboscis is guided by the groove to the nectar at the base. The stigma is first touched and thrown upwards and backwards, a movement which disturbs the loose pollen and causes a downpour. Although there is evident adaptation for cross-pollination, and I have not seen any evident modification for securing spontaneous self-pollination, still the inconspicuous flowers, partly concealed by the leaves, the shady situations in which the plant grows, as well as the apparent infrequency of insect visits, lead me to suspect that spontaneous self-pollination may occur. On May 7th, I saw the flowers visited for nectar by a single female of *Augochlora pura* Say.

Euonymus L.— The flowers have freely exposed nectar. They are usually perfect, but in England, Darwin (5) found *E. europaeus* to be polygamous and trioicous, about one-half of the plants having all of the flowers pistillate. In the Tyrol Schulz (12) found this species to have perfect flowers in most cases, less frequently andro- or gynomonoecious. Of several thousand plants, he observed but two or three with only pistillate or staminate flowers.

Among the more or less fanciful types of floral mechanisms which Delpino (4) recognizes are the *Tipo ramnaceo* and *Tipo melantino*. He regards both as adapted to the larger flies. The former contains *E. europaeus*, *latifolius*, and *japonicus;* the latter contains *E. verrucosus*, with lurid color and offensive odor. In England, Darwin saw *E. europaeus* visited by many Diptera and some small Hymenoptera. In Germany, Müller (3) saw it visited by twelve flies, mostly *Syrphidae* and

Muscidae, while in the Tyrol Schulz observed many flies, bees and wasps, and beetles. In the Berlin Garden, Loew (8, 9) saw *E. latifolius* visited by a flesh-fly, *Calliphora erythrocephala*, and our *E. americanus* visited by the hive-bee.

According to Müller *E. europaeus* is proterandrous, with spontaneous self-pollination impossible. According to Schulz the proterandry is sometimes only slight. (See 2.)

Euonymus atropurpureus Jacq. — Waahoo. — This is a small tree bearing numerous small, dark purple, pendulous flowers in loose cymes. The flowers expand horizontally for about 8 mm. In the center is situated a nearly square flat disc which secretes nectar. Each angle of the disc bears a nearly sessile anther, while in the middle is situated a stigma which is also nearly sessile. The flowers are proterandrous. The stamens and style are so short that, I think, pollen is carried mainly upon the feet and proboscides of the insects. The flower has a disagreeable odor, which, with the dark purple color, would probably place it in Delpino's *Tipo melantino*, along with *E. verrucosus*. These characters suggest an adaptation to flesh-flies, but my observations as yet do not confirm this view.

I have found the flowers in bloom from the 28th of May, to the 23d of June. The following visitors were taken on June 8, 11 and 15:—

Bees — *Andrenidae:* (1) Halictus confusus Sm. ♀; (2) H. zephyrus Sm. ♀; (3) H. stultus Cr. ♀, freq.; (4) Augochlora labrosa Say ♀; (5) A. pura Say ♀.

Diptera — *Syrphidae:* (6) Syrphus ribesii L.; (7) Allograpta obliqua Say; (8) Mesograpta marginata Say; (9) Baccha tarchetius Wlk.; *Ortalidae:* (10) Seoptera colon Lw.

Coleoptera — *Chrysomelidae:* (11) Rhabdopterus picipes Oliv.; *Mordellidae:* (12) Mordellistena ornata Melsh.— All sucking.

On the pollination of *Euonymus* see :—

(1) Fournier, De la Fécondation dans les Phanerogames, 118. 1863. Proterandry.— (2) Delpino, Altri apparecchi dicogamici recentemente osservati. Nuovo. Giorn. Bot. Ital. 2: 52. Proterandry. 1870.— (3) Müller, Befruchtung der Blumen, 153. 1873. Fertilization of Flowers, 162. 1883.—(4) Delpino, Ulteriori osservazioni. II. 2: 25, 54, 160, 214, 300, 302. 1875. Atti d. soc. Ital. d. sci. nat. in Milano 16: 173, 202, 308. 1873. 17:—. 1874. (Just 2: 883, 895). — (5) Darwin, Forms of Flowers, 287–93. 1877. (Just 5: 738)— (6) Errera et Gevaert, Sur la structure et les modes de fécondation des

fleurs. Bull. Soc. royale bot. Belgique 17: 159. 1878. *E. europaeus.*— (7) Müller, Die Stellung der Honigbiene in der Blumenwelt. III. Bienenzeitung Jahrg. 39: 157–61. 1883. *E. europaeus*, Apis wanting. (Just 11[1]: 476).— (8) Loew, Blumenbesuch von Insekten an Freilandpflanzen. Jahrb. Bot. Gartens Berlin 3: 82 (14) 1884.— (9) Loew, Weit. Beob. über den Blumenbesuch von Insekten an Freilandpflanzen. Jahrb. Bot. Gartens Berlin 4: 152. 1886.— (10) Kirchner, Flora von Stuttgart und Umgebung, 356. 1888. *E. europaeus.*— (11) Trelease, Ilicineae and Celastraceae. Trans. St. Louis Acad. Sci. 5: 349–50. 1889.— (12) Schulz, Beiträge zur Kenntniss der Bestäubungseinrichtungen und Geschlechtsvertheilung bei den Pflanzen. 2: 61, 185. Bibliotheca Botanica 17. 1890.— (13) Kerner, Pflanzenleben 2: 169. 1891. *E. europaeus.* (Just 17[1]: 531) — (14) MacLeod, Bevruchting der bloemen van Vlaanderen. Bot. Jaarboek 6: 246, 437. 1894. *E. europaeus.* (15) Loew, Blütenbiologische Floristik, 214, 378. 1894. *E. europaeus.*

Aesculus L.— Most of the observations made upon this genus were upon plants growing in Europe, where none of them are indigenous. *AE. rubicunda* is andromonoecious, with the perfect flowers proterogynous (Hildebrand 2). *AE. macrostachya* is also andromonoecious, with the perfect flowers proterandrous, and is adapted to nocturnal Lepidoptera (Kirchner 21). *AE. flava* (lutea Wang. octandra Marsh.) has most of its flowers fertile, is perforated by *Bombus terrestris*, and in the Berlin Garden is visited by hive bees (see Loew 13, 26). According to Meehan (22) *AE. parviflora* is andromonoecious. Trelease (MS. notes) saw it visited by bumble bees and by *Trochilus colubris* (10). I suspect that the Red Buckeye, *AE. pavia*, is specially adapted to humming birds.

Aesculus hippocastanum L. ("Adv. from Asia via Eu.").— Sprengel's account of this species left little to be added. He was mistaken in regarding the perfect flowers as proterandrous instead of proterogynous (2). The plant is andromonoecious, but Ogle (4) found some flowers which were pistillate from losing their anthers before dehiscence. The flowers are supposed to be adapted to bumble-bees (1, 5, 11, 19). In my yard I have seen them visited by: —

Bees — (1) Bombus americanorum F. ♀, ab.; (2) B. pennsylvanicus De. G. ♀, ab.; (3) B. separatus Cr. ♀, ab.; (4) B. virginicus Oliv. ♀, ab.; (5) B. scutellaris Cr. ♀; (6) Synhalonia frater Cr. ♂♀, ab.

Birds — (7) Trochilus colubris L.

Aesculus glabra Willd.— Coulter (12) records the fact that the flowers are andromonoecious, the perfect ones proterogynous. The trees are common and bear numerous panicles of yellowish flowers. The two lower petals are directed horizontally, lying on each side of the stamens. The two upper ones are turned upwards and form a vexillum, being marked by yellow blotches which serve as pathfinders. These by turning reddish enable the bees to distinguish the older flowers, which only serve to increase the conspicuousness of the inflorescence. The stamens and style are declined to the lower side and are curved upwards. The stamens are of unequal length and the longest are exserted 10 mm. beyond the tips of the lower petals. The anthers dehisce in succession.

Nectar is secreted by a portion of the disc which is strongly developed above and may be reached by a bee inserting its proboscis above the filaments. On account of the depth of the calyx tube a proboscis 10 mm. long is needed to do this easily. The flowers are adapted to bumble bees, which on account of the early blooming time — April 20–May 11 — are represented only by the females, and by other long tongues, such as *Anthophora* and *Synhalonia*. May 4, 5 and 9, I saw the flowers visited by the following: —

Apidae — (1) Bombus separatus Cr. ♀; (2) B. pennsylvanicus De G. ♀, freq.; (3) B. americanorum F. ♀, freq.; (4) B. virginicus Oliv. ♀; (5) Anthophora ursina Cr. ♀; (6) Synhalonia frater Cr. ♀; (7) S. belfragei Cr. ♂♀, freq., in cop.— all sucking.

On the literature of *Aesculus* see: —

(1) Sprengel, Das entdeckte Geheimniss, 209–14. 1793.— (2) Hildebrand, Geschlechter-vertheilung bei den Pflanzen, 11, 26. 1867.— (3) Axell, Om anordningarna för de fanerogama växternas befruktning, 104. 1869. *AE. hippocastanum*, cit. (2)—(4) Ogle, The fertilization of some plants. Pop. Sci. Rev. 9:54 Ja 1870.— (5) Müller, Befruchtung der Blumen, 154–6. 1873. *AE. hippocastanum, rubicunda*. — (6) Delpino, Ulteriori osservazioni. II. 2:178, 266, 268. 1875. Atti. d. Soc. Ital. d. Sci. in Milano. 16:326. 1873. 17:—. 1874. *AE. hippocastanum, rubicunda*. — (7) Errera et Gevaert, Sur la structure et les modes de fécondation des fleurs. Bull. d. Soc. roy. d. Bot. Belgique 17:146. 1878. *AE. hippocastanum*, cit. (4).—(8) Hildebrand, Die Farben der Blüthen in ihrer jetzigen variation und früheren Entwickelung, 38. 1879. *AE. hippocastanum*, color changes. (Just 7[1]:110)–(9) Bonnier, Les Nectaires. Ann. d. Sci. nat. Bot. VI. 8:107. f. 29

30. 1878. *AE. hippocastanum.* — (10) Trelease, Fertilization of flowers by humming birds. Am. Nat. 14:362. 1880.— (11) Müller, Fertilzation of Flowers, 164–6. 1883. *AE. hippocastanum, rubicunda.*— (12) Coulter, Notes on Aesculus glabra. Bot. Gaz. 8:245. 1883.— (13) Loew, Blumenbesuch von Insekten an Freilandpflanzen. Jahrb. Bot. Gartens Berlin 3: 84 (16). 1884.—(14) Urban, Zur Biologie der einseitswendigen Blütenstände. Ber. Deut. bot. Gesellschaft 3: 409. 1885. *AE. hippocastanum.*—(15) Kirchner, Neue Beobachtungen über die Bestäubungseinrichtungen einheimischer Pflanzen. Progr. d. 68 Jahresfeier d. K. Württemb. landwirtsch. Akademie Hohenheim, 31. 1886. (Just 14[1]: 790). *AE. rubicunda.*—(16) Ascherson, Der Farbenwechsel des Saft-mals in den Blüten der Rosskastanie. Naturwiss. Wachenschrift 2: 129–30. 1888. (Just 16[1]: 548)—(17) Martelli, Dimorfismo fiorale di alcune specie di Aesculus. Nuov. giorn. bot. Ital. 20: 401–4. 1888. *AE. hippocastanum, carnea, flava.* (Just 16[1]: 531. Bot. Centralblatt 36: 264.)—(18) Beyer, Die spontanen Bewegungen der Staubgefässe und Stempel. Wissenschaftliche Beilage zum Progr. d. Kgl. Gymnasiums zu Wehlau, 54. 1888. *AE. hippocastanum.* (Just 16[1]: 523)—(19) Focke, Der Farbenwechsel der Rosskastanien-Blumen. Verh. bot. Ver. Prov. Brandenburg 31: 108–12. 1889. (Just 18[1]: 473)—(20) Bail, Ueber die gelben Flecken der Rosskastanienblüte. Schr. Naturf. Gesellsch. Danzig 7: 6. 1890. *AE. hippocastanum, carnea,* color changes and sun light. (Just 18[1]: 463)—(21) Kirchner, Beiträge zur Biologie der Blüthen. Progr. z. 72 Jahresfeier d. K. Württemb. landwirtsch. Akademie Hohenheim, 30. 1890.— (22) Meehan, Contributions to the life histories of plants. V. Proc. Acad. Nat. Sci. Phila. 1890: 274–6. (Just 19[1]: 420)—(23) Kerner, Pflanzenleben 2: 179 etc. 1891. *AE. hippocastanum, macrostachya.* (Just 17[1]: 531, 533–4. 18[1]: 485)—(24) Newell, The flowers of the horse-chestnut. Bot. Gaz. 18: 107. 1893.—(25) Knuth, Blumen und Insekten auf den Nordfriesischen Inseln, 50. 1894. *AE. hippocastanum.*— (26) Loew, Blütenbiologische Floristik, 208–9. 1894. *AE. hippocastanum, rubicunda, flava, macrostachya.* See also (27) Jordan, Beiträge z. physiol. Oranographie d. Blumen. Ber. d. D. Bot. Ges. 5: 338–40. 1887. *AE. hippocastanum.*

Astragalus L.— The observations made upon this genus indicate an adaptation of the flowers to bumble-bees, though some species are also visited by other bees, such as *Megachile. A. alpinus* (6) shows a tendency to change to a butterfly-flower. In those cases in which the stigma surpasses the anthers, cross-pollination is indicated, while those in which these parts are near together have been supposed to be spontaneously self-pollinated. It seems, however, in these cases that it needs to be shown that the stigma is capable of being properly pollinated before it has been rubbed (Heinsius 19).

Of the two species which are the only ones found about Carlinville, *A. mexicanus* belongs to the spring group of

Leguminosae and blooms from April 15 to May 12, while *A. canadensis* blooms later and much longer, July 3 to August 26. These flowers illustrate what seems to be a general rule with the bumble-bee flowers of the neighborhood: the early ones visited by bumble-bee females, with accessory visits of *Anthophora* and *Synhalonia*, have the nectar more deep seated than the late flowers visited by bumble-bee workers, with accessory visits of *Melissodes* and *Megachile*.

ASTRAGALUS CANADENSIS L.— *A. carolinianus* L. — The flowers are entirely greenish-yellow, are crowded in racemes and are visited by bees crawling over them. The stigma touches the insect visitor in advance of the anthers. From the calyx tube being 4–5 mm. deep and the vexillum being strongly produced forwards the nectar is only readily exhausted by long-tongued bees. On July 7, 9, 16, 23, and Aug. 2, I saw the flowers visited by the following insects :—

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, one, vainly trying to obtain nectar; (2) Bombus separatus Cr. ☿, s.; (3) B. pennsylvanicus De G. ♀☿, s. & c. p.; (4) B. americanorum F. ☿, s. & c. p., freq.; (5) Melissodes bimaculata Lep. ♂, s.; (6) Megachile relativa Cr. ♀, s.; (7) Anthidium emarginatum Say ♂, s.; *Andrenidae:* (8) Halictus parallelus Say ♀, s., one.; *Eumenidae:* (9) Odynerus fundatus Cr., s., one.

Lepidoptera — *Rhopalocera*: (10) Nisoniades martialis Scud., s., one.

At Mt. Carmel, Illinois, Schneck (17) saw the flowers perforated by *Xylocopa virginica* Dru.

ASTRAGALUS MEXICANUS A. DC.— This is the northernmost limit of the plant in Illinois, but it is quite common. To the list of visitors given before (14) add the following observed on April 19 and 29: —

Apidae: (3) Bombus pennsylvanicus De G. ♀, s. & c. p.; (6) Anthophora ursina Cr. ♂♀, s. & c. p., freq.; (7) Osmia brevis Cr. ♀, s. & c. p.

On the literature of *Astragalus* see :—

(1) Sprengel, Das entdeckte Geheimniss, 362. 1793. *A. onobrychis.*— (2) Axell, Om anordningarna för de fanerogama växternas befruktning, 17, 73, 111. 1869. *A. oroboides, alpinus.*— (3) Delpino, Ulteriori osservazioni. Pt. II, fasc. 2: 199. 1875. Atti d. soc. Ital. d. sci. nat. in Milano 16:347. 1873. *A. alpinus.*— (4) Errera et Gevaert, Sur la structure et les modes de fécondation des fleurs. Bull. Soc. royale bot. de Belgique 17:78. 1878. *A. alpinus.*—(5) Müller, Weitere Beobachtungen. II. Verh. naturhist. Ver. preuss. Rheinl. u. Westf. 1879. 252-3. *A. glycyphyllos.*— (6) Müller,

Alpenblumen, 230–2. 1881. *A. depressus, monspessulanus, alpinus.*— (7) Loew, Blumenbesuch von Insekten an Freilandpflanzen. Jahrb. Bot. Gartens Berlin 3:96–8, 112, 116, 275, (28–30, 44, 48, 73). 1884. 8 spp.— (8) Kirchner, Neue Beobachtungen über die Bestäubungseinrichtungen einheimischer Pflanzen. Progr. 68 Jahresfeier d. K. Württemb. landwirtschaftl. Akademie Hohenheim, 41. 1886. *A. cicer.* (Just 14¹:791).— (9) *Lindman*, Blühen und Bestäubungseinrichtungen im Skandinavischen Hochgebirge. Bot. Centralblatt 30:127, 157, 158, 1887. (Biol. Centralblatt 8:198–201.) *A. oroboides, frigidus, alpinus.*— (10) Lindman, Ueber die Bestäubungseinrichtungen einigen Skandinavischen Alpenpflanzen. Bot. Centralblatt 33:59. 1888. *A. oroboides.*— (11) Kerner, Ueber das Wechseln der Blütenfarbe an einer und derselben Art in verschiedenen Gegenden. Oest. Bot. Zeit. 39:77. 1889. *A. vesicarius.* (Just 17¹:536).— (12) Schulz, Beiträge zur Kenntniss der Bestäubungseinrichtungen und Geschlechtsvertheilung bei den Pflanzen. 1:32. 1888. 2:209–10. 1890. *A. excapus, danicus, cicer, glycyphyllos.*— (13) Kirchner, Beiträge zur Biologie der Blüten. Progr. 72 Jahresfeier K. Württemb. landwirtschl. Akademie Hohenheim, 44. 1890. *A. onobrychis.*— (14) Robertson, Flowers and insects. V. Bot. Gaz. 15:199. Ag. 1890.— (15) Kerner, Pflanzenleben 2:189, 266. 1891. *A. vesicarius,* (Just 17¹:532).— (16) MacLeod, De Pyreneeënbloemen. Bot. Jaarboek 3: 438. 1891. *A. monspessulanus.*— (17) Schneck, Further notes on the mutilation of flowers by insects. Bot. Gaz. 16:313. 1891.— (18) Taubert, Leguminosae. Engler u. Prantl, Die nat. Pflanzenfamilien. L. 63, 71, 77. 1891–2. *A. depressus.* (Just 19¹:436). — (19) Heinsius, Eenige waarnemingen en beschouwingen over de bestuiving van bloemen der Nederlandsche flora door insecten. Bot. Jaarboek 4:87–91. pl. 6. 1892. *A. glycyphyllos.*— (20) Loew, Blütenbiologische Floristik. 1894. 9 spp. See also (21) Kieffer, Observations sur la Cleistogamie. Bull. Soc. Bot. Lyon 8:17. 1890. *A. monspessulanus*, semi-cleistogamous. (Just 20¹: 488.)

Stylosanthes elatior Schwartz — *S. biflora* (L.) B. S. P.— This plant has a southerly range. In Patterson's Catalogue it is credited to Jackson and Union Counties. It is rare and blooms from June 8 to September 9. The small yellow flowers have the petals and stamens inserted at the summit of the calyx-tube. The vexillum is orbicular, bright yellow and marked with a few lines forming pathfinders. As in *Crotallaria*, the wings are bright yellow and cohere at the summit, serving to cover the pale keel. The keel is somewhat incurved and closed except at base and tip. The stamens are monadelphous, but there is an opening in the base of the tube to admit the bee's tongue to the nectar. As in *Crotallaria* and *Lupinus*, five stamens have long anthers attached near their bases and five have shorter anthers attached near their middle. As soon as the flower opens, the tip of the keel is filled with

pollen from the long anthers. When the keel is depressed, the pollen is forced out in a band partly by the aid of the style and the shorter anthers, which have not yet discharged. It is quite probable that effectual pollination does not occur until the stigma has been rubbed.

The banner often extends horizontally and the keel in a vertical position. The flowers are adapted to the smallest bees and are abundantly visited for nectar by *Calliopsis andreniformis* Sm. ♀. Of nine species of *Calliopsis* occurring here, this species has the longest flight — June 3 to September 18 — extending throughout the blooming season of *Stylosanthes*.

According to Kuhn (1) *Stylosanthes* has cleistogamous flowers, but it is not stated in which of the about fifteen species close pollination occurs. Foerste (3), quoting Chapman (2), says of *S. elatior:* " It has ' flowers of two kinds: one perfect but sterile; the other destitute of calyx, corolla, and stamens, and fertile.' The fertile flowers consist therefore solely of the legume." It is needless to state that a legume is no part of a flower. It is not explained why the perfect flowers are supposed to be invariably sterile, or how the "legume" could receive pollen from the perfect flowers. Foerste says: " It is impossible to say whether the fertile flowers always were destitute of other floral envelops and organs or not." Then, speaking of the pollen of the perfect flowers, he says: " How from this place it reaches the recurved style of the fertile flower below, except by dropping off, is a mystery. Perhaps the long, bristle-like hairs on the subtending leaves and bracts serve as brushes. But even then it may be remarked that at least the earlier legumes seem already fertilized." From the above we may conclude that whether these legumes arose from perfect or cleistogamous flowers, or both, does not appear, though it is not improbable that the species has cleistogamous flowers.

Foerste infers from the horizontal position of the banner that: " Any insect visiting this flower will therefore receive the pollen on its upper side." This is not true of the *Calliopsis*, mentioned above. In fact there are a number of flowers, such as *Gerardia*, *Gratiola* and *Viola*, whose normal

visitors usually turn upside down and receive the pollen on the under side.

On the literature of *Stylosanthes* see:—

(1) Kuhn, Einige Beobachtungen über *Vandellia* und den Blüthenpolymorphismus. Bot. Zeit. 25:67. 1867.—(2) Chapman, Flora of the Southern United States, 100. 1884. [2d ed.].—(3) Foerste, Botanical notes from Bainbridge, Georgia. I. Bot. Gaz. 18:462. 1893.

Gymnocladus canadensis Lam.— *G. dioicus* (L.) Koch.— The Coffee-tree is a large tree, growing in creek bottoms and blooming from May 7 to June 1. The flowers are regular, are arranged in panicles and are said to be dioecious or polygamous. The calyx-tube is about 10 mm. long, with five equal lobes, and with five petals and ten stamens inserted near the throat. The stamens are somewhat exserted, five of them being longer than the others. The anthers are introrse, form a circle about the mouth of the calyx-tube and serve to narrow the entrance. Nectar is secreted by the inner wall of the tube.

An adaptation to bumble-bees is indicated. The following visitors were noted on May 10:—

Apidae: (1) Bombus americanorum F. ♀, s., freq.; (2) B. virginicus Oliv. ♀, s. & c. p.; (3) Synhalonia frater Cr. ♂, s.
Papilionidae: (4) Papilio troilus L., s.
Trochilidae: (5) Trochilus colubris L., s.

Spiraea L.— According to Müller (4), *S. ulmaria* is devoid of nectar and is homogamous, though Axell (2) calls it proterandrous. Cross and self-pollination may be effected by insects, or, in their absence, spontaneous self-pollination or geitonogamy may occur. According to Schulz (18), this species and *S. filipendula* are andro-monoecious. Kerner (19) calls the scent of *S. ulmaria* benzoloid.

S. filipendula is also homogamous and devoid of nectar, according to Müller. Insects effect cross-pollination; in their absence, spontaneous self-pollination takes place.

On account of their abundant nectar and pollen and their proterogynous condition, *S. salicifolia, ulmifolia* and *sorbifolia* are abundantly cross-pollinated by insects. When these fail, there may be spontaneous self-pollination (Müller). In

S. ulmifolia and *chamaedrifolia* the scent is aminoid (Kerner).

In the case of *S. opulifolia*, Ludwig (13, 14) observes that the reddish color of the ovary in old flowers, which becomes more evident in the fruit, serves to increase the conspicuousness of the plants and to draw unbidden guests away from the younger flowers. He saw the flowers visited by bees and Syrphidae.

The principal visitors of *Spiraea* are flies, especially Syrphidae, beetles, and bees, especially Andrenidae. Other flies and the lower Hymenoptera are less abundant. The following table gives the results of observations in this line: —

			Diptera.	Coleoptera.	Bees.	Other Insects.	Total.
Spiraea { salicifolia, ulmifolia, sorbifolia } mixed list.	Low Germany.	Müller (4, 8)..	46	25	20	19	110
ulmaria............	"	"	10	12	7	6	35
"	Flanders	MacLeod (24)	12	3	2	2	19
"	Scotland......	Willis (26)...	8	3	..	..	11
"	Pyrenees	MacLeod (20)	..	2	1	..	3
"	Netherlands ..	Heinsius (21).	2	..	..	..	2
"	North Frisian Islands	Knuth (25)...	1	..	..	..	1
"	Alps.........	Müller (10)...	..	1	..	..	1
filipendula.........	Low Germany.	" (4, 8).	4	4	2	..	10
"	Berlin Garden.	Loew (12)....	1	..	1	..	2
digitata............	"	"	2	2	1	..	5
aruncus	Alps.........	Müller (10)...	..	1	..	..	1
"	Low Germany.	" (4, 8).	2	6	4	3	15
"	Illinois.	....	4	30	13	4	51

Spiraea aruncus L.— *Aruncus aruncus* (L.) Karst.— I find nectar to be secreted by a perigynous disc, as observed by Delpino (5). On the other hand Müller (4, 10) states that the flowers are devoid of nectar, but he does not explain how the pistillate flowers, which of course bear no pollen, are to be visited.

According to Gray's Manual and Chapman's Flora, the flowers are dioecious, and this is the only condition in which I have found them. The staminate flowers have twenty

stamens, the anthers of the outer ten discharging their pollen before the others. The pistillate flowers have the stamens aborted. Kerner (19) mentions *S. aruncus* as typical of a group, in which some plants bear only perfect flowers, others are andro-monoecius, a third set bear only staminate and a fourth only pistillate flowers. Kerner calls the pistillate and staminate flowers pseudo-hermaphrodite, but they are so very different that they give a different aspect to the plants that bear them, enabling one to distinguish the plants at a considerable distance.

The plants bearing staminate flowers are more conspicuous from the simple fact that the numerous stamens are more conspicuous than the pistils of the fertile flowers. On this account, as well as from the fact that they yield both nectar and pollen, these plants are more abundantly visited by insects. The pistillate flowers are consequently more likely to receive the visits of insects coming from the staminate flowers.

Delpino regards *S. aruncus* as adapted to the smaller bees (micromelittofile più segnalate), or at least principally visited by them. Müller found beetles more abundant, at any rate in number of species, while I have taken a larger proportion of beetles on it than on any other flower.

The blooming time previously recorded (22) is extended from May 24 to June 24. The following list of insects, taken on the flowers on June 4, 7–10 and 20, includes the one given before, with additions and corrections :—

Coleoptera — *Dermestidae:* (1) Anthrenus musaeorum L., ab.; (2) Cryptorhopalum haemorrhoidale Lec.; (3) C. triste Lec., ab.; (4) Orphilus glabratus, F., ab.; *Nitidulidae:* (5) Epuraea truncatella Mann; (6) E. labilis Er.; *Elateridae:* (7) Sericosomus silaceus Say; *Malachidae:* (8) Anthocomus erichsoni Lec.; (9) Attalus scincetus Say; *Ptinidae:* (10) sp., freq.; *Scarabaeidae:* (11) Trichius piger F.; (12) Valgus canaliculatus F.; *Cerambycidae:* (13) Euderces picipes F., ab.; (14) Acmaeops directa Newm.; (15) Typocerus badius Newm.; (16) T. lugubris Say; (17) Leptura exigua Newm.; (18) L. vittata Germ.; (19) L. pubera Say; *Chrysomelidae*: (20) Disonycha limbicollis Lec. var. pallipes Cr.; *Bruchidae:* (21) Bruchus hibisci Oliv.; *Oedemeridae*: (22) Asclera puncticollis Say; *Mordellidae:* (23) Pentaria trifasciata Melsh., freq.; (24) Mordella marginata Melsh., ab.; (25) Mordellistena biplagiata Hel., freq.; (26) M. ornata Melsh.; (27) M. aspersa Melsh., freq.; (28) M. tosta Lec.; (29) M. pubescens F.; *Curculionidae:* (30) Centrinus picumnus Hbst., ab.— all s. or f. p.

Hymenoptera — *Apidae* (31) Heriades carinatum Cr. ♂, s.; (32) Nomada

americana Kby. ♀, s.; *Andrenidae:* (33) Halictus sp. ♀, s.; (34) H. foxii Rob. ♀. s ; (35) H. stultus Cr. ♂♀, s. & c. p., freq.; (36) Andrena platyparia Rob. ♀, s.; (37) A. cressonii Rob. ♀, s.; (38) A. flavoclypeata Sm. ♂, s.; (39) A. ziziae Rob. ♀, s.; (40) A. crataegi Rob. ♀, s. & c. p., freq.; (41) A. spiraeana Rob. ♀ s.& c. p., ab.; (42) Prosopis modesta Say ♂♀, s. & f. p., freq.; (43) P. pygmaea Cr. ♀, s.: *Eumenidae:* (44) Eumenes fraternus Say, s.; *Crabronidae:* (45) Anacrabro ocellatus Pk, s.; (46) Oxybelus frontalis Rob., s.

Diptera — *Empidae:* (47) Empis distans Lw., freq.; *Conopidae:* (48) Zodion nanellum Lw.; *Oscinidae:* (49) Siphonella cinerea Lw.; *Phytomyzidae:* (50) Phytomyza palpalis Coq. (MS.) — all s.

Hemiptera — *Capsidae:* (51) Lopidea media, Say, s.

On the literature of *Spiraea* see :—

(1) Sprengel, Das entdeckte Geheimniss, 270. 1793. *S. opulifolia.*— (2) Axell, Om anordningarna för de fanerogama växternas befruktning, 111. 1869. *S. ulmaria.*— (3) Kerner, Schutzmittel des Pollens, 36. 1873. Ber. naturh.— med. Vereines Insbruck 2 and 3:—. 1872. *S. filipendula.*— (4) Müller, Befruchtung der Blumen, 211–14. 1873. Fertilization of Flowers, 222–6. 1883.— (5) Delpino, Ulterori osservazioni II. 2:46, 96, 160, 179, 215. 1875. Atti d. Soc. Ital d. Sci. in Milano 16: 194, 244, 308, 327. 1873. 17: —. (215). 1874. *S. aruncus, ulmaria, salicifolia, ulmifolia, sorbifolia.*— (6) Lubbock, British wild flowers in relation to insects, 90. 1875.— (7) Bonnier, Les Nectaires. Ann. Sci. nat. Bot. VI. 8: 114, 115, 147. 1878. *S. ulmifolia, salicifolia, aruncus.*— (8) Müller, Weitere Beobachtungen II. Verh. d. naturhist Ver. d. preuss. Rheinl. u. Westf. 1879: 243.— (9) Henslow, On the self-fertilization of plants. Trans. Linn. Soc. II. Bot. 1: 362. (1877) 1880.—(10) Müller, Alpenblumen, 228. 1881.— (11) Müller, Die Stellung der Honigbiene in der Blumenwelt. Bienenzeit Jahrgang 38:— (No. 10) 1882. *S. ulmaria, aruncus, filipendula.* (Just 9¹:498) — (12) Loew, Blumenbesuch von Insekten an Freilandpflanzen. Jahrbuch Bot. Gartens Berlin. 3:82 (14) 1884. 4:149, 157, 159, 160. 1886.— (13) Ludwig, Ueber einem eigenthümlichen Farbenwechsel in dem Blütenstande von Spiraea opulifolia. Kosmos 2:203–5. 1884. (Just 12¹:670) — (14) Ludwig, Einige neue Fälle von Farbenwechsel in verblühenden Blüthenständen. Biol. Centralb. 6:513–14. 1886. *S. opulifolia.* (Just 14¹:806) — (15) Meehan, Botanical Notes. Proc. Acad. Nat. Sci. Phila. 1886: 60. *S. reevesiana.*—(16) Jordan, Beiträge z. physiol. Organographie d. Blumen. Ber. D. Bot. Ges. 5:333. 1887. *S. sorbifolia.* (Ludwig, Biol. Centralb. 8:204) — (17) Beyer, Die spontanen Bewegungen der Staubgefässe und Stempel. Wissensch. Beilage zum Progr. Kgl. Gymnasiums zu Wehlau, 13, 14. 1888. *S. aruncus, hypericifolia, ulmaria.*— (18) Schulz, Beiträge zur Kenntniss der Bestäubungseinrichtungen und Geschlechtsvertheilung bei den Pflanzen. 1:33. 1888. 2:186. 1890.— (19) Kerner, Pflanzenleben 2:195–6, 299, 324. 1891. Oliver Translation 2:200, 300. 1895. (Just 17¹:533. 18¹:486).— (20) MacLeod, De Pyreneeënbloemen. Bot. Jaarboek 3:426. 1891.— (21) Heinsius, Eenige waarnemingen en beschouwingen over de bestuiving van bloemen der Nederlandsche flora door insecten. Bot. Jaarboek 4:57. 1892.— (22) Robertson, Flowers

and Insects — Rosaceae and Compositae. Trans. Acad. Sci. St. Louis 6:437, 447–50, 477–9. 1894.— (23) Loew, Blütenbiologische Floristik, 85, 224. 1894. Seven species.— (24) MacLeod, Bevruchting der bloemen van Vlaanderen. Bot. Jaarboek 6:321–2, 380, 436–7. 1894.— (25) Knuth, Weitere Beobachtungen über Blumen und Insekten auf den Nordfriesischen Inseln, Schr. d. Nat. V. f. Schleswig-Holstein 10:233, 252. 1895.— (26 Willis and Burkill, Flowers and Insects in Great Britain. Ann. of Bot. 9:248. 1895.

Gillenia stipulacea Nutt. — *Porteranthus stipulatus* (Muhl.) Britton — The stems grow from 5 to 10 dm. high and are terminated by a very loose cluster of white flowers which expand from 20 to 25 mm. The stems are slightly inclined so that the flowers are thrown into an almost horizontal position, and there is a tendency on the part of the petals to assume a position somewhat as in the violet, the three lower ones extending more horizontally, and the two upper being somewhat reflexed.

The calyx-tube is quite long — 5 to 6 mm. — and narrow, the stamens and pistils being included. When the flower opens, the mouth of the tube appears quite narrow and is filled with dehiscent anthers belonging to the outer stamens. Later the innermost anthers discharge their pollen. After the anthers have become empty, the calyx-tube opens wider at the mouth, and the stigmas, which are now receptive, become visible.

The depth and narrowness of the tube render the flowers most favorable for the smaller, long-tongued bees, though they may also force their heads in for some distance. Insects cannot reach the nectar without becoming thoroughly dusted with pollen or touching the stigmas. The plant is rather frequent in woods and blooms from June 3 to 29. On the 15th, 16th and 20th the following list was observed:—

Bees — *Apidae:* (1) Anthophora abrupta Say ♂, s.; (2) Ceratina dupla Say ♂, s. & c. p., ab.; (3) C. tejonensis Cr. ♂, s.; (4) Alcidamea producta Cr. ♀, s. & c. p., ab.; (5) Heriades carinatum Cr. ♂♀, s. & c. p., freq.; (6) Osmia distincta Cr. ♀, s. & c. p., ab.; (7) O. albiventris Cr. ♀, s. & c. p.; (8) O atriventris Cr. ♀, s.; (9) Nomada affabilis Cr. ♀, s.; (10) Calliopsis parvus Rob. ♂♀, s. & c. p., ab.; (11) C. andreniformis Sm. ♂. s.; *Andrenidae:* (12) Halictus pectoralis Sm. ♂♀, s. & c. p.; (13) H. macoupi-

nensis Rob. ♀, s.; (14) H. confusus Sm. ♀, s. & c. p.; (15) H. stultus Cr. ♀, c. p., freq.

Diptera — *Conopidae:* (16) Stylogaster biannulata Say, s., freq.; *Syrphidae* (17) Pipiza pistica Will., f. p., one; (18) Baccha fuscipennis Say, f. p., one.

Lepidoptera — *Rhopalocera:* (19) Papilio troilus L., s., one; (20) Eudamus bathyllus S. & A., s.

VIBURNUM L.— In *V. opulus*, Sprengel (1) explained the significance of the more conspicuous, sterile marginal flowers. Delpino (3) includes *V. opulus* and *lantana* in his *Tipo idrangeino*, along with some species of *Hydrangea*, *Cornus* and *Sambucus*. He regards the inflorescences as favoring the visits of beetles. Sprengel observed that *V. opulus* was especially sought by beetles, and these form a majority of the insect visitors observed by Müller (2, 8), though he considered flies to be the most efficient pollinators. In Illinois I find a larger proportion of beetles on *V. pubescens* than on any other flower except *Spiraea aruncus*. After beetles, species of *Andrena* and *Empis* are next in abundance. The blooming time occurs when these insects are frequent. In the Tyrol Schulz (12) found *V. lantana* to be abundantly visited by Diptera, Hymenoptera and Coleoptera. In the Berlin Garden Loew (11) saw it visited by *Bibio laniger*. The following table gives the visitors which have been identified : —

			Coleoptera.	Empidae.	Syrphidae.	Andrenidae.	Other insects.	Total.
Viburnum opulus	Germany	Müller (2, 8)	7	1	6	1	1	16
"	Flanders	MacLeod (15)	1	1	2	..	2	6
pubescens	Illinois	....	10	4	..	8	1	23

In *V. opulus*, according to Müller (2), the flowers are crowded in a flat corymb. They are white, with short tubes, expanded borders, rather long stamens and short styles. Nectar is secreted by the upper surface of the ovary. Insects

usually effect cross-pollination. Spontaneous self-pollination may occur by the pollen falling upon the stigma. According to Kerner (13), the flowers have an aminoid scent, and geitonogamy results from the stamens diverging so far that the pollen may fall upon the stigmas of surrounding flowers.

According to Kirchner (9), *V. lantana* resembles *V. opulus*, and spontaneous self-pollination may cocur in the same way. Schulz (12) finds it proterogynous with long-lived stigmas. Spontaneous self-pollination is not the rule and is superfluous on account of the visits of numerous insects which may effect self- or cross-pollination. Kerner (13) observes a similar scent to that of *V. opulus* and the occurrence of geitonogamy in this species.

Viburnum pubescens Pursh.— According to Patterson's Catalogue, this plant has been found by Bebb, in Winnebago County, and by Vasey, in McHenry. A few plants occur here, on a high creek bank where it was first found by Andrews.

The white flowers are arranged in nearly flat-topped corymbs, which measure about 3 cm. across. The corolla forms a shallow bell about 2 mm. deep, the lobes expanding about 7 mm. Nectar is secreted by the conical base of the style, and seems to be quite abundant.

The flowers are homogamous. The stamens rise from 4 to 5 mm. above the stigma and are often so divergent that geitonogamy may occur by the pollen falling upon the neighboring stigmas. Spontaneous self-pollination may be effected in a similar way by the pollen falling upon the stigma of the same flower. Cross-pollination must often result from the abundant insect visits.

The flowers bloom from May 6th to 25th. Most of the shallow flowers blooming at the same time show a preponderance of the less specialized bees — *Andrenidae* — and flies. The preponderance of beetles in this case seems to be no kind of an accident. The following insects were taken on the flowers on May 9th:—

Coleoptera — *Dermestidae:* (1) Anthremus musaeorum L., freq., (2) Cryptorhopalum triste Lec.; (3) Orphilus glabratus F., ab.; *Scarabaeidae:* (4)

Hoplia trifasciata Say, freq.; (5) Euphoria fulgida F.; (6) Valgus canaliculatus F.; *Cerambycidae:* (7) Molorchus bimaculatus Say, ab.; *Mordellidae:* (8) Mordellistena biplagiata Hel., freq.; (9) M. aspersa Mels., freq.; (10) M. grammica Lec.— all s. or f. p.

Bees — *Andrenidae:* (11) Halictus pectoralis Sm. ♀, s. & c. p.; (12) Andrena sayi Rob. ♀, s.; (13) A. serotina Rob. ♀, s. & c. p.; (14) A. cressonii Rob. ♀, s. & c. p.; (15) A. nuda Rob. ♀, s.; (16) A. rugosa Rob. ♀, s.; (17) A. claytoniae Rob. ♀, s.; (18) Prosopis modesta Say ♀, s.

Diptera — *Empidae:* (19) Empis humile Coq. (MS.); (20) E. otiosa Coq. (MS.); (21) E. distans Lw.; (22) Rhamphomyia priapulus Lw.; *Tachinidae:* (23) Siphona illinoensis Twns.— all s.

On the pollination of *Viburnum* see:—

(1) Sprengel, Das entdeckte Geheimniss, 21, 33, 43, 82, 159–60. 1793.—(2) Müller, Befruchtung der Blumen, 364. 1873. Fertilization of Flowers, 291. 1883.—(3) Delpino, Ulteriori osservazioni. II. 2: 238, 311. 1875. Atti d. Soc. Ital. d. Sci. Milano 17:—. 1874. (Just 2: 882)—(4) Lubbock, British wild flowers in relation to insects, 108. 1875. *V. opulus.*—(5) Darwin, Forms of Flowers, 6, 7. 1877.—(6) Errera et Gevaert, Sur la structure et les modes de fécondation des fleurs. Bull. Soc. Roy. Bot. Belgique 17: 146. 1878. Fls. agamo-monoïques. (Just 6[1]: 310)—(7) Henslow, On the self-fertilization of plants. Trans. Linn. Soc. II. Bot. 1: 327. (1877.) 1880. *V. opulus.*—(8) Müller, Weitere Beobachtungen. III, 75. 1882.—(9) Kirchner, Neue Beobachtungen über die Bestäubungseinrichtungen einheimischer Pflanzen. Progr. 68 Jahresfeier d. K. Württemb. landwirtschaftl. Akad. Hohenheim, 66. 1886. *V. lantana.* (Just 14[1]: 793)—(10) Hildebrand, Ueber die Zunahme des Schauapparates bei den Blüthen. Pringsheim's Jahrbücher 17: 622–41. 1886. (Just 14[1]: 804)—(11) Loew, Blumenbesuch von Insekten an Freilandpflanzen. Jahrbuch Bot. Gartens Berlin 4: 167. 1886.—(12) Schulz, Beiträge zur Kenntniss der Bestäubungseinrichtungen und Geschlechtsvertheilung bei den Pflanzen 2: 95. 1890. (Just 18[1]: 519)—(13) Kerner, Pflanzenleben 2: 183, 195, 324. 1891. Oliver Translation 2: 187, 200, 326. 1895. *V. opulus, lantana,* peripheral fls., aminoid scent, geitonogamy. (Just 17[1]: 532–3)—(14) Fritsch, Caprifoliaceae. Engler u. Prantl, Die nat. Pflanzenfamilien. IV. 4, 159. 1891. (Just 19[1]: 409)—(15) MacLeod, Bevruchting der bloemen van Vlaanderen. Bot. Jaarboek. 5: 254, 389. 1893. 6: 372–3, 438. 1894.—(16) Loew, Blütenbiologische Floristik, 249. 1894. *V. opulus, lantana.*

SYMPHORICARPOS Jus. — The observations made upon *S. racemosus* indicate an adaptation to wasps. Although the flowers are visited by other insects, the wasps usually occur in numbers which in proportion to other guests are only observed in cases of flowers which have been regarded as wasp flowers. There is certainly nothing to indicate an adaptation to the

higher bees. The following table gives the results of observations which have been made in this line :—

			Apidae.	Andrenidae.	Vespidae and Eumenidae.	Other Hymenoptera.	Syrphidae.	Noctuidae.	Total.
S. racemosus	Oberpfalz & Westphalia	Müller (2,10,11)	6	2	7	1	1	..	17
	Paris.	Bonnier (5).....	2	1	3	....	..	..	6
	Oderberg.	Loew (12)......	1	2	4	....	5	..	12
	Belgium.	MacLeod (13)..	..	..	....	....	..	8	8
	Kiel.	Knuth (18).....	2	..	....	....	2	..	4
	Sylt.	" (19).....	2	..	....	....	..	..	2
	North Frisian Islands.	" (20).....	2	..	....	....	..	..	2
	Föhr.	" (22).....	2	..	....	....	1	..	3
vulgaris ..	Illinois.	....	..	5	7	2	..	..	14

Müller says that cross-pollination is insured in case of insect visits, but self-pollination can hardly occur in their absence. Henslow (7) regards spontaneous self-pollination as probable, but admits that it is less likely when the flowers are pendulous. This, however, according to Müller, is their normal position.

From observations of Delpino (14) it appears that nectar is secreted by the corolla and not by the swollen base of the style, as claimed by Müller. In this Loew (21) states that Delpino is anticipated by Kurr (1), but Kurr's observations were on *S. vulgaris*.

Symphoricarpos vulgaris Michx. — *S. symphoricarpos* (L.) Mac M. — In Patterson's Catalogue this species is not credited to Illinois. It agrees in a general way with Müller's account of *S. racemosus*. The flowers are collected in axillary clusters. They are commonly pendulous, but vary from that position to erect. The corolla tube is about 2 mm. long and expands at the throat about 3 or 4 mm. It is greenish-white with a trace of rose color. The nectar is concealed by hairs arising from the inner wall of the corolla near the insertion of the filaments. The stamens occupy a position near the corolla wall and have introrse anthers which surpass the stigma. The flowers are homogamous. Wasps coming with their noses covered with pollen are more likely to effect cross-

pollination than otherwise, but they may also effect self-pollination by carrying pollen back to the stigma. In weather unfavorable for insect visits, spontaneous self-pollination is quite likely except in the pendulous flowers.

The flowers bloom from July 8 to Sept. 10. The following list, the result of observations made on July 8, 11, 12, 19, 25, and Aug. 30, seems to be a very natural one, for after the *Vespidae* and *Eumenidae* one would expect to find *Andrenidae* and lower Aculeata.

Hymenoptera — *Andrenidae:* (1) Halictus coriaceus Sm. ♂; (2) H. stultus Cr. ♀; (3) Agapostemon radiatus Say ♂; (4) Augochlora viridula Sm. ♀; (5) A. pura Say ♀; *Vespidae:* (6) Polistes pallipes Lep.; *Eumenidae:* (7) Eumenes fraternus Say, ab.; (8–10) Odynerus spp., ab.; (11) O. foraminatus Sauss., freq.; (12) O. conformis Sauss.; *Sphecidae:* (13) Ammophila vulgaris Cr.; *Pompilidae:* (14) Pompilus philadelphicus Lep. — all sucking.

On the pollination of *Symphoricarpos* see:—

(1) Kurr, Untersuchungen über die Bedeutung der Nektarien, 55. 1832. *S. vulgaris.* (2) Müller, Befruchtung der Blumen, 360–1. 1873.— (3) Delpino, Ulteriori osservazioni. Pt. II. fasc. 2:212, 321. 1875. Atti d. soc. Ital. d. sci. Milano 17:—. 1874. *S. racemosus.*— (4) Müller, Die Insekten als unbewusste Blumenzüchter, Kosmos 3:485-6. 1878. *S. racemosus.* (Just 6^1: 313) — (5) Bonnier. Les Nectaires. Ann. d. Sci. nat. Bot. VI. 8:37, 138. f. 106. 1878.—(6) Müller, Die Wechselbeziehungen zwischen den Blumen und den ihre Kreuzung vermittelnden Insekten. Encycl. der Naturwiss. Breslau. 5:—.Schenk, Handbuch der Botanik (65). 1879. *S. racemosus.* (Just 7^1: 98) — (7) Henslow, On the self-fertilization of plants. Trans. Linn. Soc. Bot. II. 1:366. (N 1877) 1880.— (8) Trelease, Note on the perforation of flowers. Bull. Torr. Bot. Club, 8: 69. 1881. *S. racemosus.*— (9) Müller, Die Entwickelung der Blumenthätigkeit der Insekten. Kosmos 9: 266, 272. 1881. *S. racemosus.* (Just 8^1: 148) — (10) Müller, Weitere Beobachtungen. III. 73. Verh. naturhist. Ver. preuss. Rheinl. u. Westf. 1882.—(11) Müller, Fertilization of Flowers, 292. 1883.—(12) Loew, Weitere Beobachtungen über Blumenbesuch von Insekten an Freilandpflanzen. Jahrb. Bot. Gartens Berlin 4: 99. 1886.—(13) MacLeod, Untersuchungen über die Befruchtung der Blumen. Bot. Centralblatt 29: 119. 1887. (Just 14^1: 793) — (14) Delpino, Il nettario florale del Symphoricarpus racemosus. Malpighia 1: 434. 1887. (Just 15^1: 431) — (15) Cocconi, Contributo allo studio dei nettari mesogamici delle Caprifogliaceae. Memor. accad. sci. istit. Bologna 9: 279–85. 1888. (Just 16^1:552).—(16) Ludwig, Die Blütennectarien des Schneeglökchens und der Scheebeere. Biol. Centralblatt 8:225–6. 1888. (Just 16^1: 553) — (17) Fritsch, Caprifoliaceae. Engler und Prantl, Die nat. Pflanzenfamilien. IV. 4:159. 1891.— (18) Knuth, Blütenbiologische Herbstbeobachtungen. Bot. Centralblatt 49: 267. 1892.— (19) Knuth, Vergleichende Beobachtungen über den Insektenbesuch an Pflanzen der Sylter Haide und der Schleswigschen Festlandshaide. Bot. Jaarboek

4: 40, 41. 1892.— (20) Knuth, Blumen und Insekten auf den Nordfriesischen Inseln, 81. 1894.—(21) Loew, Blütenbiologische Floristik, 147, 250, 391. 1894. *S. racemosus.*— (22) Knuth, Weitere Beobachtungen über Blumen und Insekten auf den Nordfriesischen Inseln. Schr. d. Nat. V. f. Schleswig-Holstein, 10: 235. 1895.

ASTER ERICOIDES L. var. VILLOSUS Torr. & Gr.— *A. ericoides pilosus* (Willd.) Porter — This is a common plant, having rather small heads with yellow discs and white rays. It blooms from Aug. 21 to Oct. 17. The following visitors were taken on the flowers on Sept. 14, 18, 20–24, 26, 28 and Oct. 8 and 10 :—

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s.; (2) Bombus virginicus Oliv. ♂☿, s. & c. p.; (3) B. americanorum F. ♂☿, s.; (4) B. separatus Cr. ♂☿, s.; (5) Melissodes confusa Cr. ♂♀, s. & c. p., freq.; (6) M. nivea Rob. ♀, s. & c. p., freq.; (7) M. autumnalis Rob. ♀, s. & c. p., ab.; (8) Ceratina tejonensis Cr. ♂, s. freq.; (9) C. dupla Say ♀, s.; (10) Megachile latimanus Say ♀, s. & c. p.; (11) Heriades carinatum Cr. ♀, s. & c. p.; (12) Coelioxys altilis Cr. ♀, s.; (13) C. dubitata Sm. ♀, s.; (14) Epeolus cressonii Rob. ♀, s.; (15) E. illinoensis Rob. ♂♀, s.; (16) E. pectoralis Rob. ♀, s.; (17) E. donatus Sm. ♀, s.; (17) Nomada vicina Cr. ♂, s.; (18) Calliopsis asteris Rob. ♂♀, s. & c. p.; in cop., ab.; (19) C. compositarum Rob. ♂♀, s. & c. p., in cop., ab.; (20) C. andreniformis Sm. ♀, s. & c. p.; (21) Perdita 8-maculata Say ♀, s. & c. p.; *Andrenidae:* (22) Halictus foxii Rob. ♀, s.; (23) H. coriaceus Sm. ♂, s.; (24) H. ligatus Say ♂, s.; (25) H. pilosus Sm. ♂, s.; (26) H. confusus Sm. ♂, s.; (27) H. stultus Cr. ♂, s.; (28) Agapostemon viridula F. ♀, s. & c. p.; (29) A. radiatus Say ♀, s.; (30) Augochlora pura Say ♀, s.; (31) A. similis Rob. ♀, s.; (32) Andrena asteris Rob. ♂♀, s. & c. p.; (33) A. solidaginis Rob. ♂♀, s. & c. p., freq.; (34) A. nubecula Sm. ♀, s. & c. p.; (35) Colletes americana Cr. ♂♀, s. & c. p., freq.; (36) C. compacta Cr. ♂♀, s. & c. p., freq.; (37) Sphecodes stygius Rob. ♀, s.; (38) Prosopis pygmaea Cr. ♀, s.; (39) P. modesta Say ♀, s.; *Vespidae:* (40) Vespa maculata L.; (41) V. germanica F., freq.; (42) V. cuneata F.; (43) Polistes metricus Say; (44) P. annularis L.; (45) P. pallipes Lep.; *Eumenidae:* (46) Eumenes fraternus Say; (47) Odynerus sp.; (48) O. capra Sauss.; (49) O. campestris Sauss.; (50) O. tigris Sauss.; (51) O. forminatus Sauss.; (52) O. anormis Say; *Mimesidae*: (53) Mimesa cressonii Pack.; *Philanthidae:* (54) Cerceris clypeata Dlb.; (55) C. fulvipes Cr.; *Sphecidae:* (56) Ammophila gracilis Lep.; *Scoliidae:* (57) Scolia bicincta F.; *Ichneumonidae:* (58) Metopius polycinctorius Say var.— all s.

Diptera — *Empidae:* (59) Empis clausa Rob. (MS.); *Bombylidae:* (60) Argyramoeba albofasciata Mcq.; (61) Anthrax alternata Say, freq.; (62) Sparnopolius fulvus Wd.; (63) Systropus macer F., freq.; (64) Toxophora amphitea Wlk.; *Conopidae:* (65) Zodion fulvifrons Say; (66) Z. nanellum Lw.; *Syrphidae:* (67) Syrphus ribesii L., freq.; (68) S. americanus Wd.; (69) Xanthogramma emarginata Say: (70) Allograpta obliqua Say; (71) Mesograpta marginata Say; (72) M. geminata Say; (73) Sphaerophoria cyl-

indrica Say; (74) Eristalis dimidiatus Wd.; (75) E. tenax L., freq.; (76) E. latifrons Lw.; (77) E. aeneus F.; (78) Helophilus similis Mcq.; (79) H. latifrons Lw.; (80) Tropidia mamillata Lw.; (81) Syritta pipiens L.; (82) Spilomyia longicornis Lw., freq.; (83) S. quadrifasciata Say; *Tachinidae:* (84) Gymnopareia americana Twns.; (85) Besseria atra Coq. (MS.); (86) Jurinia apicifera Wlk.; (87) Belvosia bifasciata F.; (88) Peleteria robusta Wd.; (89) Siphoplagia anomala Twns.; (90) Micropalpus fulgens Mg.; (91) Acroglossa hesperidarum Will., freq.; (92) Siphona illinoensis Twns.; *Dexidae:* (93) Ptilodexia abdominalis Desv.; *Sarcophagidae:* (94) Sarcophaga sp.; (95) Helicobia sp.; (96) H. helicis Twns.; *Muscidae:* (97) Lucilia sp.; (98) L. cornicina F.; (99) Compsomyia macellaria F.; (100) Musca domestica L.— all s. or f. p.

Lepidoptera — *Rhopalocera:* (101) Phyciodes tharos Dru.; (102) Pyrameis huntera F.; (103) Thecla melinus Hbn.; (104) Pieris protodice Bd.-Lec.; (105) Meganostoma caesonia Stoll; (106) Colias philodice Gdt.; (107) Pyrgus tessellata Scud.; *Heterocera:* (108) Scepsis fulvicollis Hbn.; (109) Feltia subgothica Steph.; (110) Heliothis armiger Hbn.; (111) Drasteria erichto Gn.— all s.

Coleoptera — *Lampyridae:* (112) Chauliognathus pennsylvanicus De G.; *Cerambycidae:* (113) Cyllene robiniae Forst.; *Chrysomelidae:* (114) Diabrotica longicornis Say; *Meloidae:* (115) Epicauta pennsylvanica De G. — all f. p.

Hemiptera — *Capsidae:* (116) Lygus pratensis L., s.

Silphium perfoliatum L.—The cup-plant is common in low grounds along streams. The stems grow two or three metres high and bear yellow heads which expand six to seven, or more, centimetres. The disc florets yield nectar and pollen, the ray florets being pistillate. The tubes of the disc florets are rather large and measure about 5 mm. in length. This secures the visits of the longer-tongued insects. The blooming season is from July 9th to Sept. 12th. The following visitors were noted on July 23, 31, Aug. 3, 4, 9, 13, 15–17, and Sept. 12:—

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s. & c. p., freq.; (2) Bombus americanorum F. ♂ ☿, s. & c. p.; (3) Melissodes bimaculata Lep. ♂, s.; (4) M. obliqua Say ♂ ♀, s. & c. p.; (5) M. agilis Cr. ♂, s., freq.; (6) M. perplexa Cr. ♂ ♀, s., freq.; (7) M. dentiventris Sm. ♂, s., freq.; (8) M. confusa Cr. ♂, s.; (9) M. coloradensis Cr. ♂ ♀, s. & c. p.; (10) Ceratina dupla Say ♀, s.; (11) Megachile petulans Cr. ♂, s.; (12) M. mendica Cr. ♀, s.; (13) M. brevis Say ♀, s. & c. p.; (14) Epeolus concavus Cr. ♂ ♀, s.; (15) E. lunatus Say ♂ ♀, s.; (16) Calliopsis labrosus Rob. ♂, s., freq.; (17) C. rugosus Rob. ♂ ♀, s.; *Andrenidae:* (18) Halictus lerouxii Lep. ♀, s.; (19) H. ligatus Say ♀, c. p.; (20) H. pilosus Sm. ♀, c. p., freq.; (21) H. confusus Sm. ♀, c. p.; (22) H. stultus Cr. ♀, c. p., freq.; (23) Agapostemon viridula F. ♀, s. & c. p.; (24) A. radiatus Say ♀, s. & c. p.; (25) Augochlora

pura Say ♀, s.; (26) Andrena pulchella Rob. ♂, s., freq.; (27) A. aliciae Rob. ♀, s.; *Scoliidae:* (28) Scolia bicincta F., s.

Diptera — *Bombylidae*: (29) Exoprosopa fasciata Mcq., s.; (30) Anthrax halcyon Say, s.; (31) A. alternata Say, f. p.; (32) Systoechus vulgaris Lw., s., freq.; (33) Sparnopolius fulvus Wd., s.; *Conopidae:* (34) Zodion leucostoma Will., s.; *Syrphidae:* (35) Allograpta obliqua Say, f. p.; (36) Eristalis transversus Wd., f. p.; *Tachinidae:* (37) Jurinia smaragdina Mcq., s.

Lepidoptera — *Rhopalocera:* (38) Danais archippus F.; (39) Papilio philenor L.; (40) Pamphila cernes Bd.-Lec.; (41) P. otho S. & A. var. egeremet Scud.— all s.

Heliopsis laevis Pers.— *H. helianthoides* (L.) B. S. P.— The plants are common, grow one metre, or more, high, and bear numerous orange-yellow heads, which expand about 5 cm. The ray florets are pistillate. The disc florets are perfect, yield nectar and pollen, and have tubes 3 to 4 mm. long. The blooming time is from July 1 to Sept. 28. The following visitors were taken July 16, 31, Aug. 1, 3, 6, 7, 12, 13, 15, 17, 21, 22; Sept. 10, 12:—

Hymenoptera — *Apidae:* (1) Melissodes perplexa Cr. ♂, s.; (2) M. coloradensis Cr. ♂, s.; (3) M. obliqua Say ♂, s.; (4) M. dentiventris Sm. ♂♀, s.; (5) Ceratina dupla Say ♀, s.; (6) Megachile brevis, Say ♂, s., freq.; (7) Coelioxys altilis Cr. ♂♀, s.; (8) Epeolus lunatus Say ♂♀, s., freq.; (9) E. fumipennis Say ♂, s.; (10) E. concavus Cr., s.; (11) E. cressonii Rob. ♂, s.; (12) Phileremus heliopsis Rob. ♂, s.; (13) Calliopsis labrosus Rob. ♂♀, s. & c. p.; (14) C. rugosus Rob. ♂, s., freq.; *Andrenidae:* (15) Halictus pectoralis Sm. ♀, c. p.; (16) H. ligatus Say, ♀, s.; (17) H. pruinosus, Rob. ♀, s. & c. p.; (18) H. obscurus Rob. ♂, s.; (19) H. pilosus Sm. ♀, s. & c. p.; (20) Augochlora labrosa Say ♀, s. & c. p.; (21) A. pura Say, ♀, s.; (22) Andrena aliciae Rob. ♀, s.; *Philanthidae:* (23) Cerceris sp.; *Sphecidae:* (24) Ammophila vulgaris Cr. s.; *Scoliidae:* (25) Scolia bicincta F., s.

Diptera — *Empidae:* (26) Empis clausa Rob. (MS.), freq.; *Bombylidae:* (27) Exoprosopa fasciata Mcq.; (28) E. fascipennis Say.; (29) Anthrax halcyon Say; (30) Systoechus vulgaris Lw.; (31) Sparnopolius fulvus Wd.; (32) Geron calvus Lw., freq.; (33) G. rufipes Mcq.; *Syrphidae:* (34) Eristalis transversus Wd.— all s.

Lepidoptera — *Rhopalocera:* (35) Phyciodes tharos Dru.; (36) Thecla melinus Hbn.; (37) Pieris protodice Bd.-Lec.; (38) Pholisora catullus F.— all s.

Coleoptera — *Lampyridae:* (39) Chauliognathus pennsylvanicus De G., s.

Hemiptera — *Lygaeidae:* (40) Lygaeus turcicus F., s.

Rudbeckia laciniata L. — The stems grow two or three metres high, are considerably branched and bear numerous heads with yellow discs and rays. The heads expand 8–9

cm., but the rays are inclined to droop. The discs soon become elevated into a conical globular form. The ray florets are neutral. Those of the disc are perfect, with erect lobes and admitting an insect's proboscis to the extent of 3 mm. The plant is common and blooms from July 17 to September 28. The following visitors were observed on August 13, 15, 17, 22, 26, 31, and September 10 and 12:—

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s. & c. p., ab.; (2) Bombus separatus Cr. ☿, s. & c. p.; (3) B. americanorum F. ☿, s.; (4) Melissodes obliqua Say ♀, c. p.; (5) M. dentiventris Sm. ♂♀, s. & c. p., freq.; (6) M. coloradensis Cr. ♂, s.; (7) M. autumnalis Rob. ♂, s.; (8) M. confusa Cr. ♂, s.; (9) Calliopsis labrosus Rob. ♂♀, s. & c. p., freq.; (10) C. rudbeckiae Rob. ♂♀, s. & c. p., freq.; *Andrenidae:* (11) Halictus ligatus Say ♀, s. & c. p.; (12) Andrena aliciae Rob. ♀, s. & c. p., freq.; (13) Colletes compacta Cr. ♂♀, s. & c. p., freq.; *Bembecidae:* (14) Bembex fasciata F., s.; *Sphecidae:* (15) Ammophila gracilis Lep., s., freq.; (16) A. intercepta Lep., s.; *Scoliidae:* (17) Scolia bicincta F., s.

Diptera — *Empidae:* (18) Empis clausa Rob. (MS.), s., freq.; *Bombylidae:* (19) Exoprosopa fasciata Mcq., s.; (20) Anthrax halcyon Say, s.; (21) A. alternata Say, s.; (22) Systoechus vulgaris Lw., s., (23) Sparnopolius fulvus Wd., s.; *Syrphidae:* (24) Syrphus ribesii L., f. p.; (25) Eristalis transversus Wd., s.; (26) E. dimidiatus Wd., s.; *Tachinidae:* (27) Jurinia smaragdina Mcq., s.; (28) Peleteria robusta Wd., s., freq.; (29) Cyphocera fuesta V. d. W., s.; (30) Acroglossa hesperidarum Will., s.

Lepidoptera—*Rhopalocera:* (31) Phyciodes nycteis Db.-Hew.; (32) Lycaena pseudargiolus Bd.-Lec.; (33) Pamphila cernes Bd.-Lec.; *Heterocera:* (34) Scepsis fulvicollis Hbn. — all s.

Cacalia reniformis Muhl.— The stems grow from 5 to 15 dm. high and are terminated by rather large flat-topped corymbs of white heads. Each head contains five tubular perfect florets. These open in succession, the ones in the second stage being bent aside so that the stigma cannot touch the anthers of the younger flowers. The tubes are about 6 mm. long, very narrow below, but opening above into a wider portion about 2 mm. long. Insects only insert their proboscides into the wider part of the tube. The plant blooms from June 25 to Aug. 1. The following insects were taken on the flowers on June 25 and July 2, 8 and 16:—

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s.; (2) Melissodes bimaculata Lep. ♀, s.; (3) Ceratina tejonensis Cr. ♂, s.; (4) C. dupla Say ♀, s.; (5) Heriades carinatum Cr. ♀, s. & c. p.; *Andrenidae:* (6) Halictus foxii Rob. ♂, s.; (7) H. pectoralis Sm. ♂♀, s.; (8) H. cressonii Rob. ♂, s.;

(9) H. zephyrus Sm. ♀, s.; (10) H. confusus Sm. ♀, s. & c. p. freq.; (11) H. stultus Cr. ♀, s.; (12) Agapostemon radiatus Say ♂, s.; (13) Augochlora labrosa Say ♀, s. & c. p., freq.; (14) A. viridula Sm. ♂♀, s., freq.; (15) Prosopis modesta Say ♂, s.; (16) P. pygmaea Cr. ♂, s.; *Eumenidae:* (17) Eumenes fraternus Say; (18) Odynerus sp.; (19) O. tigris Sauss., freq.; (20) O. dorsalis F.; (21) O. fundatus Cr., freq.; (22) O. quadrisectus Say; (23) O. perennis Sauss.; *Crabronidae:* (24) Crabro interruptus Lep.; *Sphecidae:* (25) Ammophila gracilis Lep.; (26) A. intercepta Lep.; (27) A. vulgaris Cr.— all s.

Diptera — *Tipulidae:* (28) Geranomyia canadensis West.; *Empidae:* (29) Empis clausa Rob. (MS.) freq.; *Conopidae:* (30) Zodion nanellum Lw.; (31) Oncomyia loraria Lw.; *Syrphidae:* (32) Sphaerophoria cylindrica Say; (33) Syritta pipiens L.; *Tachinidae:* (34) Miltogramma argentifrons Twns.; (35) Siphona illinoensis Twns., freq.; (36) Siphophyto floridensis Twns.— all s.

Lepidoptera — *Heterocera:* (37) Sesia sexfasciata Edw., s.

Hemiptera — *Lygaeidae:* (38) Melanocoryphus bicrucis Say; *Capsidae.* (39) Lopidea media Say, freq. — both s.

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339

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THE PHILOSOPHY OF FLOWER SEASONS, AND THE PHAENOLOGICAL RELATIONS OF THE ENTOMOPHILOUS FLORA AND THE ANTHOPHILOUS INSECT FAUNA.

BY CHARLES ROBERTSON.

The writer's determination to discuss the subject of flower seasons at the present time is owing to the publication, by Mr. Henry L. Clarke, of an interesting and suggestive paper on the same topic in the NATURALIST for September, 1893. Having been engaged since 1886 in the investigation of the mutual relations of flowers and insects, he has been led in a very natural way to consider the time of blooming of flowers adapted to insects and the time of flight of the insects which depend more or less upon a floral diet. In 1890 a tabulation of both groups was begun, based upon the data then at hand, and since that time the author has had lying before him lines indicating the periods of the separate species and curves indicating the periods of the families of entomophilous plants and of the genera of bees, and the families of the principal remaining anthophilous insects; all, however, in the process of being modified by the accumulation of data. As a result, certain views have been arrived at regarding the relations of the

periods of particular flowers to particular species of insects, of families of plants to certain groups of insects, and the relative positions of different groups. Under these circumstances, Mr. Clarke's paper was read with particular interest, though it has not seemed to justify an abandonment of theoretical conclusions previously held.

The factors admitted by Mr. Clarke to have an influence in determining the blooming time of flowers are as follows:

1. "The blooming period may sometimes vary from the general rule to better bring the flowers among the most favorable conditions for cross-fertilization."

2. "Again, plants that are frontiersmen from the characteristic vegetation of a hotter clime may be expected in the hottest of the seasons—*e. g.*, the Cactaceae."

3. "There is an evident limitation of the flowering of our trees and shrubs to spring and earliest summer." "The blossoming of so many trees, especially the Diclinae, in earliest spring, before leaf-budding, must evidently have at least partial connection with anemophilous cross-fertilization."

4. "Again, there is a determining function in the character of the flower's habitat—the spring flowers seek largely the protection of the woodlands; marsh plants reach perfection mainly in latest spring and through the summer, though some, like Caltha, are early; the aquatics of ponds and river glory in the summer sun; and the flowers of meadow and prairie and thicket margin luxuriate from midsummer to the end of autumn."

But the principal deductions of Mr. Clarke are these: "*From early spring to late autumn there is a progression in the general character of the flower groups, from the lower to the higher—successive groups succeeding each other in time, parallel groups coming synchronously.* And the later in order may be *types* of a higher character of development, or they may be *specializations* of a group whose *normal* forms belonged to an earlier season. In their blooming season, *the more perfect succeed the more simple; the aberrant, the normal; the specialized, the g[illegible]ralized.*"

In the solution of the problem of the flower seasons of a given flora I think that the period of no plant should enter as a factor, if it is so far removed geographically that at its blooming time it does not become a competitor of any plant of that flora. Any number of flowers adapted to the same conditions may bloom at the same time if they are so widely separated that they do not interfere with one another, but it would be an obvious disadvantage for very many of them to bloom at the same time in the same locality. In the latter case a separation of the blooming times would be advantageous. On the other hand, there are some objections to the use of data derived from a local flora, though I think they are not so serious. Phenomena which seem to find an explanation in a limited field may in fact find their true explanation in conditions outside of that field. Even in the case of a local flora the time of blooming is likely to be indicated as too long, since it is based upon the early dates of early seasons, and the late dates of late ones. Such data give rise to error by making it appear that the period of an early species overlaps with that of a later one when in fact the two species never have flowers in bloom at the same time in any season. It is hardly practicable to avoid this, since observations confined to a single season are liable to be too fragmentary.

To note that a given family of plants is highly specialized and that it agrees with Mr. Clarke's generalization by reaching its maximum in summer, does not help one to understand either the general position of the family or the blooming time of a single species, and the difficulty remains the same whether the species blooms before or after the bulk of the family, or whether its season coincides with the maximum. The main fault that may be found with his elucidation of the subject is that it is implied that the general principle of the late blooming of highly specialized flowers is an explanation of the blooming phenomena: for, whenever a flower agrees with the generalization, it is left as if it were thus explained, while, if it is an exception, its period is accounted for under the considerations which we have numbered. And it must have been a striking fact to the readers of the paper that the exceptions yielded so

readily to these considerations that they remained the only cases which were clearly elucidated. But it is hardly fair to dwell too strongly upon this point, for towards the close of the article, Mr. Clarke has expressly said: "Here the question rises, why should there be a correspondence between the course of the flower seasons and the system of floral evolution? Solve this and the 'Philosophy of flower seasons' is an open riddle." Stated in this way, as a very interesting and important fact to be explained, I see little in the paper to which objection can be made. Otherwise, it might not unfairly be considered as an attempted refutation of the Darwinian flower theory, for what becomes of that theory if it can be shown that the time of blooming of insect-pollinated flowers is not correlated with the time of flight of flower-loving insects?

The object of this paper will be to attempt a preliminary contribution to the subject from the standpoint of data derived from the *indigenous* local flora near Carlinville, Illinois (lat. 39° 21′), to test Mr. Clarke's main proposition, to undertake to account for flower seasons as a result of the competition of plants for the services of various pollinating agencies, and those of insect-loving flowers as also correlated with the flight of flower-loving insects, and to attempt an explanation of the fact of the general preponderance of the most highly specialized flowers in late summer.

When a plant in a plastic condition succeeds in establishing itself in a highly favorable position, it throws off a number of closely allied forms which finally become more or less well marked incipient species. As a result we find a number of nearly related forms in competition for a similar position in the soil, for a favorable position in the sunlight, and for the aid of the same pollinating agency. The process of producing similar forms may go on until the competition becomes so severe that it becomes disadvantageous. Then it becomes advantageous for some of the forms to avoid competition[1] with the dominant group by migrating to a different region, or to a different kind

[1] In the interaction of organisms in the struggle for existence it strikes me that a law of avoidance of competition is more obvious than that of the survival of the fittest.

of soil, to modify their floral characters so as to attract a different set of visitors, or to separate their times of blooming so that they may not have to compete with a great many similar flowers for the attention of the same kinds of insects. As a consequence we find the forms separating their blooming times so as to come, some before, and some after, the maximum of the group, though the maximum of the whole will probably coincide with the position of the maximum of the dominant forms. The maximum point, then as a rule, at least, marks the point of origin of the group, but the struggle for existence requires a departure from it. Instead, therefore, of indicating a point of convergence for the group, the maximum point is the place of divergence, so that there is no law[2] according to which the forms tend to concentrate at this point. If one of the forms which has departed from the maximum point comes to fill a much more favorable position, it may finally give rise to so numerous a progeny of forms that the maximum of the group will change position and no longer coincide with the point of origin.

In looking over my tabulations with these considerations in mind I note that, as a rule, incipient and closely allied species bloom synchronously, while more distinct species, and species of different genera are more likely to be widely separated. In large genera containing numerous closely allied species, which indicates a more recent origin, most of the species bloom together, and it is a notable fact that such genera have a potent influence in determining the maximum point of the groups to which they belong. Thus the species of buttercups (*Ranunculus*), violets (*Viola*), St. John's wort (*Hypericum*), tick-trefoil (*Desmodium*), golden-rods (*Solidago*), boneset (*Eupatorium*), sunflower (*Helianthus*), aster, milkweed (*Asclepias*), verbena, and smartweed (*Polygonum*), with rare exceptions, bloom simultaneously. The maximum of the buttercup family (Ranunculaceae) coincides with that of *Ranunculus*, that of Leguminosae with the position of *Desmodium*, while the maximum

[2] In the migration of some highly specialized groups which MacMillan calls "north bound," I think there has been a retardation of the blooming seasons which has tended to concentrate the species and thus form late maxima.

of Compositae is determined by the position of the asters, *Eupatorium*, golden-rods and sunflowers.

As a result of the divergence of the blooming periods from the maximum point of the group we find that plants come into competition with species of other groups, but as a rule they can stand this better than competition with their own allies.

Trees have such a remarkable influence upon one another and upon the herbaceous flora that they should properly, it seems, be considered separately. The fact that most of them agree in being wind-pollinated is an additional reason for this course. Of 488 indigenous insect-pollinated plants, upon which my observations are based, only 18 are trees. On examining the curve for the insect-loving flora (Fig 1, Plate VIII, 5 species to the millimetre),[3] it will be observed that the maximum is reached in August. At this time 187 species are in bloom, but not a single tree is among them. The flowers of trees are so interfered with by their own leaves and the leaves of other trees that it is disadvantageous for them to bloom after the leaves are fully developed. In the case of wind-pollinated trees it is obvious that, if the leaves were developed before the flowers, the process of pollination would be greatly impeded by the leaves interfering with the free circulation of the wind and catching the pollen which is intended for the stigmas. This fact makes trees an evident exception to Mr. Clarke's generalization, though they are frequently less specialized than their later flowering allies. In the anemophilous nettle family (Urticaceae) there is a marked contrast between the blooming times of the trees and herbaceous species, as stated by Mr. Clarke. Thus the elm, hackberry and mulberry are early, while the hop, hemp and wood-nettle (*Laportea*) are late.

In the case of insect-pollinated trees the conditions are similar to those of wind-pollinated ones, and they generally

[3] Unless otherwise specified, the curves given in this paper are on the scale of one species to the millimetre, *i, e.*, the height of the curve in millimetres indicates the number of insects flying, or flowers in bloom at a given time. The details on which the curves are based will be given elsewhere.

bloom before the leaves are developed, the witch-hazel notably after the leaves have fallen. The leaves act in an equally disadvantageous way, by concealing the flowers so that insects do not easily find them. Before the leaves have appeared in the woods, the trees which depend upon insects for pollination are very conspicuous and have a good chance of being attended by the insects which are attracted by their own flowers and by the flowers of the herbaceous plants which grow under their protection. Later, when the woods become shady, there are few herbaceous flowers, and few insects to attend the trees if they should bear flowers dependent upon them. The rose family (Rosaceae) is of particular interest, since of the larger families it contains the greatest number of trees., and as its maximum is early (Fig. 14, Plate VIII), it is the only one of the entomophilous tree-producing families, which is in a favorable position for giving rise to aborescent forms. The first to bloom is the service-berry (*Amelanchier*), and the trees, *e. g.*, the plum, cherry, apple and hawthorn, coincide pretty nearly with the maximum of the family, though it is significant that the latest species are herbaceous. As the season advances, the flowering of trees and of herbaceous plants which grow under them is evidently cut short in correlation with the appearance of the overshadowing leaves.[4]

While it is not my intention to discuss wind-pollinated plants specially at this time, I think that their blooming seasons may be explained by reference to their competition among themselves and with the insect-pollinated flora. Even in herbaceous plants it seems that the spring might reasonably be expected to be the most favorable for pollination, since they would be less likely to be overtopped by the later plants which become increasingly more luxuriant. But at different seasons they can readily occupy positions unfavorable to entomophilous plants, and in summer they may endure the competition of the entomophilous flora better than that of an indefinite number of plants depending upon the wind, or better

[4] One of my favorite botanizing grounds shows a great variety of vernal flowers, but after the appearance of the leaves is covered by a uniform growth of the anemophilous wood-nettle (*Laportea canadensis*).

than to resort to insect-pollination. In the cases of anemophilous Ranunculaceae, such as meadow-rue (*Thalictrum*), and Compositae, such as rag-weed (*Ambrosia*), it is probable that wind-pollination has been resorted to by way of avoiding competition with their allies, and it is notable that these plants bloom near the maximum points of the families to which they belong.

A comparison of the insect-pollinated Monocotyledons (Fig. 7, Plate VIII) with the general entomophilous flora (Fig. 1, Plate VIII) yields a more striking contrast than would result from a comparison of the two groups in general, for the former loses the large wind-loving families of sedges and grasses, the latter blooming late, and the general flora loses the early blooming wind-loving trees. In this group we observe that the terrestrial species, without regard to specialization, bloom early, while the aquatic ones are late. This I think is largely a result of the severe competition of the former with the highly specialized terrestrial flora, a competition from which the aquatics have been largely relieved by their position.

As regards those of the Liliiflorae having the carpels separate (apocarpal) and those having them united (syncarpal) I am unable to agree that the former are more highly specialized, and so must consider that their blooming time is opposed to the proposition that the more highly specialized flowers bloom later.

The curve for the Choripetalae (Polypetalae and Apetalae, Fig. 2, Plate VIII.—5 spp. per mm.) shows a maximum in August of 73 species, and a secondary maximum in April of 71 species, and the curve diminishes from both to about the middle of June, when there are 49 species in bloom. Of the Hypogynae (Fig. 3, Plate VIII.—2 spp. per mm.) 43 species bloom simultaneously in May, after which they pretty regularly decline. With the addition of the hypogynous Apetalae, the maximum remains the same, but there is a secondary elevation in August. The Perigynae (Fig. 5, Plate VIII. —2 spp. per mm.) show an August maximum on account of the strong preponderance of the Leguminosae. Among the

Epigynae (Fig. 4, Plate VIII) the ginsengs (Araliaceae), dogwoods (Cornaceae), wild ginger and pipe-vine (Aristolochiaceae), as Mr. Clarke observes, come early. In regard to the Umbelliferae (Fig. 18, Plate VIII), however, my observations do not show them "in fullest sovereignty in July and August," for at that time only four species bloom together, while there are 11 species in flower in May. Contrary to Mr.Clarke's theory, the more highly specialized Epigynae (Fig. 4, Plate VIII) show a stronger tendency than the Perigynae (Fig. 5, Plate VIII to form an early maximum.

Even the less specialized of the two dominant families of Perigynae (the Rosaceae, 14) does not equal the Umbelliferae in the formation of an early maximum, *i. e.*, it does not decline so rapidly from the early elevation. I think that the Umbelliferae are more highly specialized than the Myrtales (Lythraceae and Onagraceae) and so reverse the order of Mr. Clarke's theory. But the maximum of the Myrtales (17) anticipates that of the Leguminosae (15).

Of the hypogynous Sympetalae (Gamopetalae), the phloxes (Polemoniaceae), water-leaf family (Hydrophyllaceae) and borage family (Borraginaceae) are early; of 12 species all but one begin to bloom before June, and only two are in bloom after July 1st (Fig. 20, Plate VIII). The more numerous mint family (Labiatae, Fig. 13, Plate VIII) and Scropulariaceae (Fig. 19, Plate VIII) predominate in the summer. Observations on the Epigynae indicate that the flowers of the honeysuckle and madder families (Caprifoliaceae and Rubiaceae) are most abundant in the last of May and first of June. The lobelias and campanulas are most abundant in August. Of all the dominant families, the, Compositae (Fig. 21, Plate IX.—2 spp. per mm.) show the latest maximum. The tendency of the more highly specialized Sympetalae to form a strong late maximum is more marked than in the case of the more simple Choripetalae.

In order to illustrate to what extent the time of blooming of plants is correlated with the time of flight of insects, curves are reproduced showing the periods of the principal flower-loving insects, *e. g.*, the bees (Fig, 24, Plate IX), the other

Aculeate Hymenoptera (Fig. 25, Plate IX), the butterflies (Fig. 23, Plate IX), and the flies (Fig. 22, Plate IX)—all on the scale of five species to the millimetre. No curve is made out for the whole because these curves agree in showing a maximum for July, which, of course, would determine the position of the general maximum.[5] The bees are by far the most important, since they depend upon flowers both for their own food and for that of their young. As a rule, except in the case of the cuckoo bees, which lay their eggs upon food deposited by the host bees, the female bees are provided with brushes of hair upon which they carry pollen, the essential part of the bee-bread, upon which the larvæ feed.

In a previous examination of the curve for the Choripetalae (Fig. 2, Plate VIII) there was observed a maximum in August, a secondary elevation in May, and an intervening depression in June.

With the principal exception of the Leguminosae (Fig. 15, plate VIII), these plants have horizontally expanded regular flowers, with readily accessible nectar and stamens exposed so that the pollen is easily collected or eaten. The Leguminosae generally have lateral irregular flowers, with the nectar concealed and deep-seated, and intricately concealed pollen, for which reason they will be separated for special consideration. Now, since the maximum for the Choripetalae coincides with that of the Leguminosae, the separation of this family will change the maximum of the group to the secondary point. There are two families of insects which are particularly fond of simple flowers with easily accessible nectar and pollen—the less specialized bees (Andrenidae, Fig. 26, Plate IX.—2 spp. per mm.) and the flower-flies (Syrphidae, Fig. 36, Plate X.—2 spp. per mm.)—and they both have more species flying in early spring. There is no question but that the strong predominance of the more simple Choripetalae is, to a great extent, correlated with the early predominance of the Andrenidae and Syrphidae. The flowers of the buttercup family (Ranunculaceae, Fig. 9, Plate VIII) and of the Rosaceae (Fig.

[5] My phaenological observations are most defective for August. I expect to find the maximum of the general anthophilous insect fauna a little later.

14, Plate VIII) with their numerous stamens are the particular favorites of the less specialized bees, and it would be fairly impossible for them to be so efficiently attended late in the season. No flowers are more convenient for the imperfectly adapted flower insects than those of the parsley family (Umbelliferae, Fig. 18, Plate VIII). While the later blooming species are visited by a more numerous set of insects, the visitors are less efficient. The flowers are somewhat neglected by the higher bees (Apidae, Fig. 27, Plate IX.—2 spp. per mm.). so that in order to secure the most useful set of visitors it is desirable to bloom early, under the maximum of the Andrenidae. I have shown that the harbinger of spring (Erigenia), the earliest spring flower, has a larger percentage of bees among its visitors than any other plant of the family, and that the early blooming species with simply concealed nectar show more bees as visitors than those with deep-seated nectar but blooming late. On consulting the curves for bees (24) and other Aculeate Hymenoptera (25) and flies (22), it will be observed that early in the season the predominant insects are bees and flies, so that by early blooming the less specialized flowers gain an advantage similar to that secured by the more highly specialized in a later season in concealing their nectar, *i. e.*, they acquire a higher proportion of the more efficient flower insects. The pond lilies (Nymphaeaceae) come in bloom late, probably on account of their aquatic habitat and have a long period, probably on account of occupying a position free from the competition of overshadowing form, but they are pollinated by late-flying bees and flower flies; and I have named two species of bees (*Halictus nelumbonis* and *Prosopis nelumbonis*) on account of their close economic relation to these flowers. The violets (Fig. 16, Plate VIII) are spring flowers, there being no normal late-blooming indigenous species. Those with the lateral petals bearded are adapted to the mason bees (Osmia, Fig. 31, Plate IX), small greenish species with pollen-collecting brushes on the ventral surface of the abdomen, which fly early apparently to avoid competition with the large allied genus of leaf-cutter bees (Megachile, Fig. 32, Plate IX). When visiting the violets these

bees turn head downwards and hang upon the beards of the lateral petals while they collect the falling pollen. The violets also have an important pollinator in *Andrena violæ* of the spring group of *Andrena* (Fig. 35, Plate X). The swamp rose-mallow (*Hibiscus lasiocarpus*, Fig. 6a, Plate VIII) has a blooming time correlated with the time of flight of a characteristic American bee (*Emphor bombiformis*, Fig. 6b, Plate VIII), its principal pollinator; the bee in turn depending on the *Hibiscus* for its pollen. Another interesting case of correlation in appearance and mutual dependence is, that of an alum-root (*Heuchera hispida* Fig. 11a, Plate VIII) and a little bee (*Colletes aestivalis*, Fig. 11b, Plate VIII).

Returning to the Leguminosae (Fig. 15, Plate VIII) we observe that of the species which form the August maximum all are adapted to the most intelligent of the highest specialized genera of bees. Quite a number are bumble-bee flowers. The ordinary flowers have the stamens declined to the lower side and are best fitted to be pollinated by the leaf-cutter bees (Fig. 32, Plate IX), which have abdominal brushes for collecting pollen, and I think that the position of the family in general should be regarded as associated with the flight of these bees. Two species adapted to bumble-bees, a ground plum (*Astragalus mexicanus*) and a false indigo (*Baptisia leucophaea*), occur early, which they may do without going out of the range of bumble-bees (Fig. 30, Plate IX) and they each gain an advantage by avoiding competition with a late blooming congener also depending upon bumble-bees. But no other ordinary papilionaceous flower blooms out of the flying time of the leaf-cutter bees. The very earliest of the family, the red-bud (*Cercis canadensis*) has the stamens declined to the lower side of the flower, so that the pollen is easily gathered by the mason bees (Fig. 31, Plate IX), which we have already mentioned as having abdominal brushes, like the leaf-cutters (Fig. 32, Plate IX), but fly early. The early appearance of the red-bud seems to be influenced by the early flight of these bees, though it is not exclusively visited by them. Finally, therefore, with regard to the blooming phenomena of the Choripetalae, we close with the propositions that the early preponderance of the

more simple open flowers is determined by the early predominance of the less specialized bees, and that the late preponderance of the more complicated closed flowers is correlated with the flight of the most specialized bees, leaf-cutters, bumblebees, etc.[6]

The Sympetalae (Gamopetalae) consist of flowers with more or less deepseated nectar and often with closed complicated flowers. They are adapted to bumble-bees or to the more highly specialized bees in general, to butterflies or to miscellaneous more or less long-tongued insects. An interesting case is that of flowers of *Steironema* which are associated with the flight of *Macropis steironematis*, a bee which as far as observed depends exclusively upon these flowers for its pollen. The wild potato vine (*Ipomoea pandurata*) is dependent mainly upon two bees (*Entechnia taurea* and *Xenoglossa ipomoeae*). The flowers of ground cherry (*Physalis*) bloom during the flight of two species of *Colletes* (*C. willistonii* and *C. latitarsis*), upon which they depend almost exclusively for pollination, the little bees on the other hand, obtaining all of their pollen from these flowers. The dominant mint family (Labiatae, Fig. 13, Plate VIII) is principally adapted to the higher bees, although some having degraded irregular flowers with exposed stamens are adapted to miscellaneous insects. The figwort family (Scrophulariaceae, Fig. 19, Plate VIII) is an even more exclusive bee-flower family, most of them being adapted to bumble-bees, and appearing late. The earliest species, *Collinsia verna*, is one of the most highly specialized and looks like a papilionaceous flower. The upper lip and the lateral lobes of the lower lip represent banner and wings, while the middle lobe represents the keel, and it performs the same function for it contains the stamens, which instead of lying against the upper wall of the corolla, as is usual in the family, are declined across the tube. We have observed that most of the Leguminosae with declined stamens are adapted to bees with abdominal

[6] The early blooming of the dominant families of Choripetalae, as well as the Liliiflorae, must also be explained in part as correlated with their woodland habitat, their decline being influenced by the appearance of the leaves on the trees.

pollen brushes (*Megachile*, Fig. 32, Plate IX), and now in the case of this flower we find the principal visitors to be bees of the genus *Osmia* (Fig. 31, Plate IX) ; so that it joins the red-bud and violet in appearing during the flight of these bees. The figwort (*Scrophularia*) and *Symphoricarpus* come late in adjustment to the flight of the wasp workers and Eumenidae to which they are specially adapted. The late position of the lobelias is what might be expected, since they are dependent upon the visits of the higher bees (Fig. 27, Plate IX). We come finally to consider the great highly specialized family of sunflowers, nigger-heads, thistles, etc., (Compositae, Fig. 21,–2 spp. per mm. Plate IX) which shows a conspicuous late maximum and is the best example of Mr. Clarke's theory, though I think one of the easiest to explain without it.

The composite heads, which give the name to the family, are composed of florets arranged generally in a flat-topped horizontal layer which forms a convenient resting place for all kinds of insects. There is abundant nectar for the longer tongues and abundant pollen exposed for the least specialized to feed upon or to collect. From these peculiarities and from their great numbers we find this family to be of more importance to the general insect fauna than any other. The most important visitors are the higher bees, especially bumble-bees (Fig. 30, Plate IX), the leaf-cutters (Fig. 32, Plate IX) and *Melissodes* (Fig. 29, Plate IX), and lower Aculeate Hymenoptera in general (Fig. 25, Plate IX), the butterflies (Fig. 23, Plate IX), the flies, including many flower-flies (Fig. 36, Plate X), the tachinids (Fig. 37, Plate I), the conopids (Fig. 38, Plate X), and the bombylids (Fig. 39, Plate X). The occurrence of the maximum of the family after that of the general flower-loving insect fauna, I think, is largely due to the abundance of the goldenrods, asters, etc., which have rather small heads and less-deeply concealed nectar. The position of these flowers is accounted for in correlation with the position of the usually smaller insects by which they are attended, viz.; the little bees belonging to the genera *Calliopsis* (Fig. 34, Plate IX), the late *Colletes* (Fig. 33, Plate IX), the autumnal group of *Andrena* (Fig. 35, Plate X) and the Bombylidae (Fig. 39, Plate X)—all important guests

and all having late maxima. These late Compositae have few competitors outside of their family and so are favorably situated, although the insect fauna has begun to decline. We will now leave the Sympetalae with the general statement that the late preponderance of the irregular flowers is explained in connection with the late preponderance of the higher bees, and that of the regular flowers is accounted for in the late maxima of the highly specialized long-tongued insects.

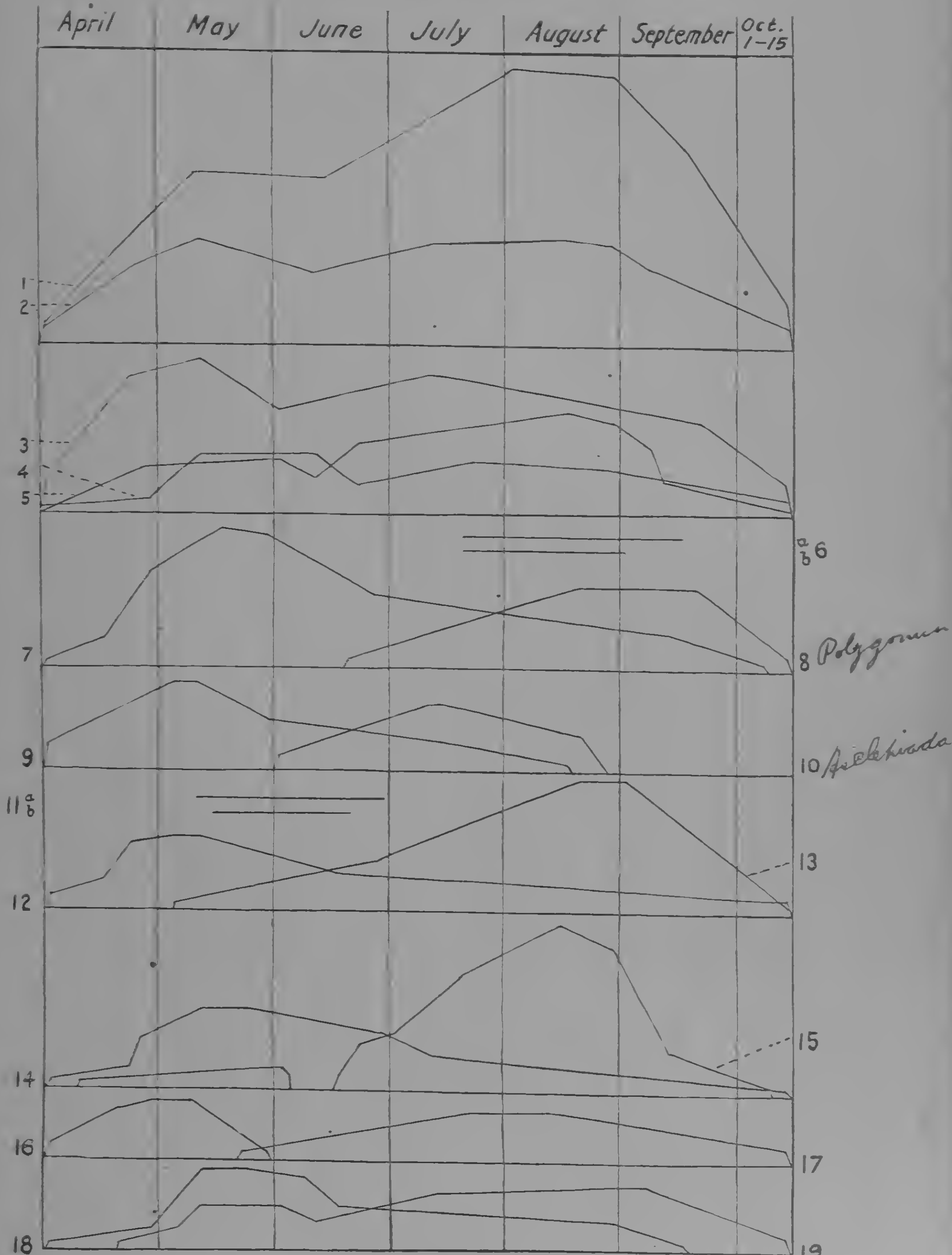
We have reviewed the principal groups of insect-pollinated plants and have noted a correspondence, more or less well marked, between their blooming seasons and the seasons of the insects upon which they depend. In different positions we find bumble-bee flowers and, although they all occur within the time of flight of these insects, it is not easy to explain why one of these flowers comes at one time and another at another time. Under the maximum of the buttercup family (Fig. 9, Plate VIII) we find a bumble-bee flower in the larkspur (*Delphinium tricorne*) and under the maximum of Leguminosae (Fig. 15, Plate VIII) another in a tick-trefoil (*Desmodium canadense*). We may say that the larkspur comes earlier because it had its origin in an earlier group. The flight of the bumble-bees, however, cannot be left out of consideration. It is obvious that a bumble-bee flower cannot arise at a time when the attentions of bumble-bees cannot be secured, so that the flight of the bees determines the time within which these flowers may have their origin. When a flower undergoing modification to suit bumble-bees changes its characters so that it no longer comes in competition with its allies, it becomes a competitor of other bumble-bee flowers. A point at which many of these are in bloom simultaneously would naturally be an unfavorable time, unless the new form should early offer more inviting attractions. If the blooming time were long, the attentions of the bees would be likely to be most constant at the point where there were the fewest competitors, and so finally the blooming time would tend to be limited to this point. Or if the earlier flowers were better tended, so that they became the most effectually fertilized, the blooming time would tend to become earlier. Some flowers we find far from the "tension" points

of their groups, having no doubt shifted to take a more favorable position under the competition of other flowers. Thus the earliest member of the mint family (Fig. 13, Plate VIII), is a bumble-bee flower, and some of the earliest of the figwort family (Fig. 19, Plate VIII) are adapted to these insects. The larkspur itself is anticipated by four bumble-bee flowers belonging to more highly specialized families. We would, therefore, expect to find bumble-bee flowers at favorable points of origin or shifted to favorable positions, and the whole group of flowers so disposed as to share the services of these long-tongues with as little interference among themselves as possible. Of the sixty-four species on which the curve (Fig. 41, Plate X) is based the different forms succeed one another from the first of April until the middle of October in such a way that not more than twenty-five species are in bloom at the same time. Twenty-six have completed their flowering by the last of June. We will compare this curve with that for bumble-bees. The first bumble-bees which fly in the spring are the females; in May, June and July the workers appear; and finally in July, the males. The workers are more abundant and even more industrious than the females, and the males are frequently quite numerous and efficient flower visitors. In making a curve for bumble-bees (Fig. 30, Plate IX), therefore, I have introduced each sex as an element so that the maximum coincides with the flight of the three forms, and I think this is the only way to indicate in a curve the function of the genus as a pollinating agency. Now if we compare the curve for bumble-bees (Fig. 30, Plate IX) with the curve for the bumble-bee flowers (Fig. 41, Plate X) we find a well marked coincidence.

The curve for the other flowers adapted to the higher bees (Fig. 44, Plate X) indicates a more pronounced maximum, evidently because the higher bees in general show a more marked preponderance in summer. Of sixty-nine species on which the curve is based, thirty are in bloom simultaneously at the maximum point.

Now as observed above, the lower bees (Andrenidae, Fig. 26 Plate IX) prefer erect simple flowers with easily accessible nectar

PLATE VIII.


April
May
June
July
August
September
Oct. 1–15
1
2
3
4
5
a b 6
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8 Polygonum
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10 Asclepiada
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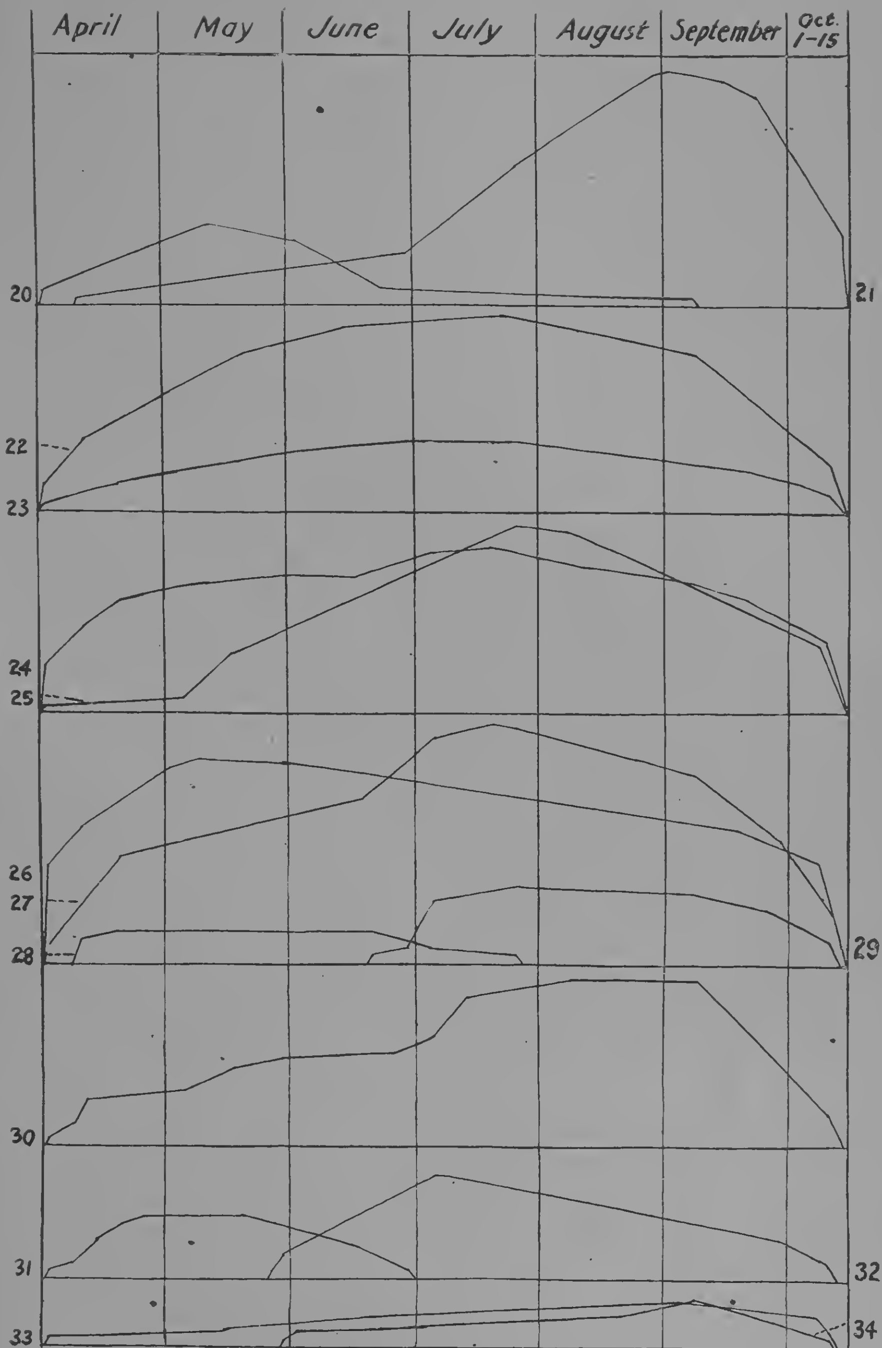
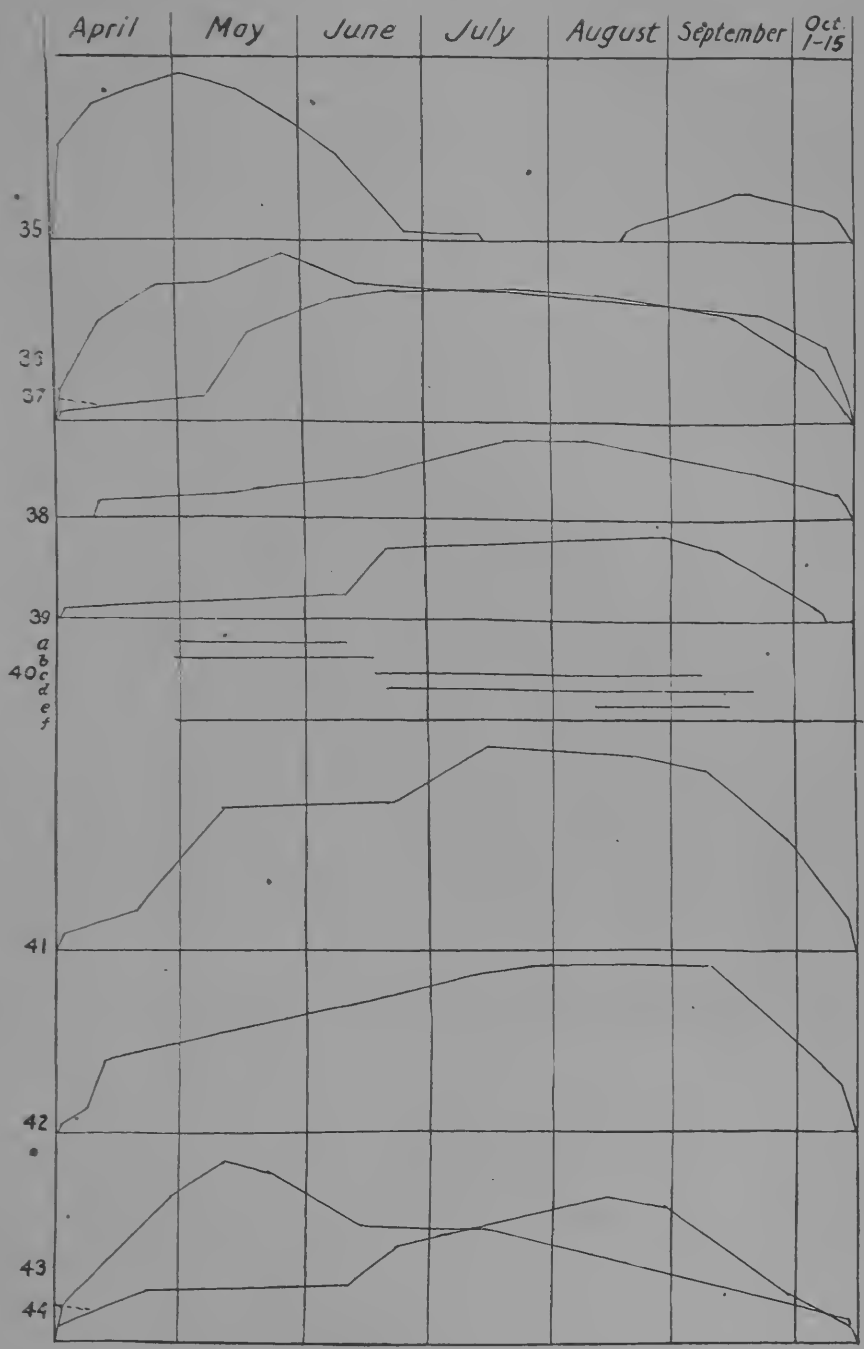
PLATE IX.



28 Anthophora + Synhalonia

PLATE X.



April
May
June
July
August
September
Oct. 1-15
35
36
37
38
39
a
b
40c
d
e
f
41
42
43
44

and exposed pollen, especially flowers with numerous stamens. There are many flowers which have a structure of this kind and on which these bees actually preponderate over every other family of flower-loving insects. But since they do not hold a clear preponderance over the total of the other groups, it is hardly safe to call the flowers "Andrenid-flowers." The large family of flower-flies (Syrphidae, Fig. 36, Plate X) has the proboscis adapted for eating pollen and for sucking, though as a suctorial organ it is not so highly specialized as in many other flies. For this reason the flowers which are best fitted to supply the Andrenidae with nectar and pollen are also the most favorable for the nectar and pollen-eating Syrphidae, and when these two families are taken together they generally show a preponderance over all other visitors, or so many that the flower may be properly regarded as adapted to them. Putting such flowers together, I find that the *ensemble* of their blooming periods forms a curve like Fig. 43, Plate X, with a strong early maximum.

There are few evident butterfly-flowers. The best marked of them are commonly visited by long-tongued bees and flies. The species which are referred to this category form a long low curve, which we will compare with the curve for butterflies (Fig. 23, Plate IX).

Fig. 40, Plate X shows the time of flight of the ruby-throated humming bird (f) and the time of blooming of the flowers specially pollinated by it.—a. the painted cup (*Castilleia coccinea*); b. the wild columbine (*Aquilegia canadensis*); c. the trumpet creeper (*Tecoma radicans*): d. the spotted touch-me-not (*Impatiens fulva*); e. the cardinal flower (*Lobelia cardinalis*). There are two early species blooming together and going out about the time that the trumpet creeper (c) comes in, and three late species. The position of painted cup (a) is peculiar, but is much more favorable than in competition with the three late species. It will be noted that two species are in competition most of the time, while it is only a short time that one is alone or three are together. The spring and autumn migration of the bird may account for the tendency of these bird flowers to form an early and a late group.

The insects which contain what may properly be called flower-loving groups, viz.: the Hymenoptera, Diptera and Lepidoptera, are the most highly specialized orders of insects. The particular anthophilous groups we have observed to have their maxima in the late summer. With the exception of the bees, which are true flower-insects, depending upon flowers and showing true mutual correlations, the flight of these insects may be more properly regarded as determined by conditions favorable for their young. Flowers and flower-groups blooming at times favorable for utilizing them should be regarded as correlated with the time of flight of the insects, and not visa versa. Of the bees we have observed that the highest specialized (Apidae) show a late maximum while the less specialized (Andrenidae) show an early maximum, which is explained largely as a result of competition of the former. In view of the fact, therefore, that the most highly specialized flower-insects are most abundant in late summer it is but natural that there should also be a preponderance at the same time of the most highly specialized flowers whose development has been simultaneous with them. In so far as it applies to insect-pollinated flowers I think we have here the answer to Mr. Clarke's question "Why should there be a correspondence between the course of the flower seasons and the system of floral evolution?"

We have observed that the group in which the fact of the correlation of a high specialization and late flowering is very conspicuous is the Sympetalae, and it must be admitted that the proposition of Mr. Clarke in regard to the late blooming of plants of southern derivation, must enter as an explanation. In his admirable work on the Metaspermae of the Minnesota Valley, Mr. MacMillan has shown that the Sympetalae (Metachlamydeae) are especially characterized by a north-bound movement.

Throughout this paper it has been implied that the time of blooming was determined by the flight of the pollinating insects and also determined and limited by the competition of plants one with another. In verification of this view turn to the case of introduced plants. It is well-known that intro-

duced plants seem to flourish much more prosperously than the natives, and this is explained as owing to the fact that in a new country they escape the competition of forms which have been constantly undergoing modification to hold them in check. Many of our introduced plants, however, are not characterized so much by the facility with which they crowd out native species as by their habit of adjusting themselves to conditions induced by man, and of filling places rendered by him unoccupied; and in this work many of them no doubt have undergone a course of selective training in older lands. But it is sufficient for our purpose to start with the fact that introduced plants are to a great extent relieved from the pressure of competition which holds among the indigenous plants, and, therefore, as regards blooming, would be expected to flower longer. And this is in fact the rule. In those genera in which we have both indigenous and introduced species the former bloom for a short time (*Sisymbrium canescens*, *Stellaria longifolia*, *Cerastium nutans*, sunflowers, thistles) while their introduced congeners bloom much longer (*Sisymbrium officinale*, *Stellaria media*, *Cerastium vulgatum*, *Helianthus annuus*, *Cnicus lanceolatus*). The introduced species of Cruciferae, Caryophyllaceae, Portulacaceae, Malvaceae, Leguminosae, Umbelliferae, Compositae, Scrophulariaceae, Labiatae and Polygonaceae present cases of long blooming which are not equaled by any native species of the respective families.

Some native plants which have a strong tendency to occupy waste grounds also show a tendency to bloom for a long time. A similar disposition is manifested in the cases of plants having small flowers infrequently visited by insects and often self-pollinating. Many originally aquatic plants and others which have been forced to take to the water are, like introduced plants and the degraded entomophilous flowers, relieved from the severer competition of terrestrial plants and in a similar way show a tendency to prolong their blooming periods.

In the case of the indigenons flora there is a well marked disposition to limit the blooming period in anticipation of the advancing winter. The direct effect of cold is not obvious, but there is an evident tendency not to prolong the period

until the conditions should become unfavorable for the perfection of the fruit. In the case of the north bound groups (Sympetalae especially) we might infer that the northward movement would retard the blooming time so as to make it later in beginning, and to prolong it far into the autumn. I have thought that this might have something to do with the late preponderance of these groups. The curves for Labiatae (Fig. 13, Plate VIII) Compositae (Fig. 21, Plate IX) and Leguminosae (Fig. 15, Plate VIII) seem to show the influence of the approaching cold to an unusual degree, for they fall off quite suddenly from the late maxima. In the case of introduced plants we have observed that they show in a low degree the limitations which beset the indigenous species and so tend to prolong their periods. The advancing winter brings conditions, however, which they cannot escape, and it is but natural that they should show the direct effect of cold more than the indigenous plants. They form a low curve which is relatively higher at the 15th of October than any other curve. Although only about one-tenth of the entomophilous species, the introduced species show two-fifths of the flowers in bloom at the middle of October. Their blooming time is actually cut short by the cold.

An interesting fact in regard to the curves for the dominant groups of flowers is that they decline towards June. In the curves for the general flora and the Choripetalae and its groups (1–5) it will also be observed that there is a depression in June. The same occurs in Scrophulariaceae (Fig. 19, Plate VIII), while the Leguminosae (Fig. 15, Plate VIII) show an actual gap, as far as I have observed. This results mainly I think from the appearance of the dense shade in the woodlands, which limits the blooming seasons of the vernal woodland species. No plant can become a strong competitor of the vernal species unless it blooms early enough to fill out its season before the shade appears. The late species are thus required to modify their seasons so greatly before they are prepared to enter the vernal woodlands that the trees finally become as effectual a barrier against them as against the late blooming of the early species. Suppose that the Compositae should give rise to an

early flowering group which should enter the woodlands and become competitors of the spring flora, as *Antennaria* and some species of *Erigeron* now do. The curve for Compositae would finally show a June depression. These conditions must always keep the groups from taking the positions required by Mr. Clarke's theory.

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367

Index

H

I

K

L

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